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Effect of Varying Water Temperature on Germination of Selected Tree Species in Delta State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author ECI designed the study. Author FEA collected data. Author ECI performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors DDE and OK managed the literature searches and editorials. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aims: Effective seed germination is a prerequisite for successful tree planting project. Effect of varying water temperature on germination of selected tree species was examined.
Study Design: 4 X 4 factorial experiments in Completely Randomized Design with 3 replicates.
Place and Duration of Study: Experiment was conducted in the laboratory of Science Laboratory Technology of Delta State University, Abraka between June 12 and July 26, 2023.
Methodology: Twenty-four seeds each of *Terminalia mantaly* (TM), *Senna siamea* (SS), *Delonix regia* (DR), *Polyalthia longifolia* (PL) were randomly selected and soaked at varying durations in cold-water (12^0C- 24hrs, 48hrs, 72hrs and 0hrs); warm-water (40^oC- 5mins, 10mins, 15mins and 0mins); hot-water (100^oC-30secs, 60secs, 90secs and 0secs) and control. A 4 X 4 factorial

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experiment in Complete Randomized design was adopted. Data on days to germination, sprouts and germination percentage were obtained and analyzed using ANOVA at $\alpha_{0.05.}$

Results: Germination and soaking duration of seeds in cold-water were not significant (P>0.05). Seeds of SS and PL recorded the least and highest days to germinate (11.92±2.31 and 15.30±2.31) and sprout (14.83±2.39 and 18.10±2.39), respectively. One seed each of *SS* soaked for 24 and 48 hours germinated at day 4 with 66.7% germination (at week 2). Hot-water had significant effect (P<.05) on germination and sprout of seeds while soaking duration and interaction were not significant for germination. Seeds of SS and DR performed best with (6.67±1.33 and 7.58±1.33; 8.42±1.62 and 10.50±1.62) average days to germinate and sprout, respectively. Seeds of SS (60 seconds) and DR (30 seconds) germinated and sprouted within 5 and 8 days with 91.7% germination (weeks 2). Warm-water had significant (P<.05) effect on germination, sprout and soaking duration of seeds. Seeds of SS germinated and sprouted at 6.42±0.78 and 9.57±0.88 days respectively, with earliest days to germinate (5.00±2.22-10mins) and sprout (8.00±2.14- 5mins). DR soaked in warm-water for 10 mins germinated and sprouted within 4 and 8 days after planting. At week 2, seeds of SS and DR had 91.7% germination.

Conclusion: Seed pretreatment contributed to the germination of species as no seed was damaged.

Keywords: Pre-treatment; seed dormancy; germination; tree species.

1. INTRODUCTION

Towns and cities are dominated by over half of human population. With increased migration and birthrate, human dominance in cities is heightened (UN 2014). When cities are properly planned and administered, they are great habitat for man. However, urbanization causes environmental challenges from deforestation to heat islands, flooding and air pollution. The effects of environmental hazard to man are reflected in deteriorating well-being; for the earth, increased greenhouse gas emissions, waste pollution, degradation of soils, altering of waterways and disruption of bio-geochemical circle that maintain the health and sustainability of the earth's ecosystem.

Trees are important components of any landscape as they benefit the environment by providing ecosystem services such as natural filters, carbon sequestration, storm-water mitigation, and air-quality improvements (Oldfield et al., 2015) and serve as safety net against storms since they act as windbreak thus protecting infrastructures (Borelli et al., 2015).Trees benefit man by providing fruits, shades, woods, seeds, latex and improve the physical and mental health of citizens (Ohwo et al., 2020). Cities need forests. Forest beautifies cities and enhances social cohesion (Ohwo et al., 2024). The act of planting, maintaining, monitoring, and managing tree population in urban areas to ensure that trees benefit the people via providing and protecting is termed urban forestry. The activities of Urban forestry involve planting, maintaining and removing trees, tree inventory, pest monitoring and plant health care, tree risk assessment, planning for future tree planting and management, and educating the public on the benefits and care of trees and advocating on behalf of the urban forest (Vogte, 2020).

Trees are planted either via sexual or asexually. Sexually, Seed germination is the basic form of tree propagation. Seeds can germinate quickly and establish seedlings in time under suitable environmental conditions, which can increase the probability of successful afforestation exercise. For tree planting programs to succeed, it is important to secure viable, genetically superior seeds in adequate quantity. It is challenging to regenerate most tree species because of inherent slow growth, problems of irregular fruiting, pests and diseases, seed dormancy and environmental factors (Oboho and Ogana, 2012).

Baskin and Baskin (2004) noted that impervious seed coat sometimes stimulates physical dormancy in seeds, thus, must be broken to allow air and water into seed embryo for germination to occur. Most coats of seeds of tree species are impervious to water causing seed dormancy, and extend germination over several months (Odoi et al., 2019). Seed dormancy is broken naturally or artificially. Artificially, seed dormancy is broken by pre-treatments which involve the imitation and utilization of natural dormancy breaking procedure (Azad et al., 2010).

Temperature and water have been identified as important environmental factors for seed germination (Hu et al., 2020). High temperatures (hot water) within a certain temperature range are conducive to seed germination, while excessively high and low temperatures outside a certain range are disadvantageous (Yan et al., 2016). The right temperature for seed germination is comparatively restricted, while some seeds have the tendency to germinating at a specific temperature. However, this is not uniform between species (Iralu et al., 2019. Varying pre-sowing treatments (acid, cold, water, hot water, endocarp removal, and seed coat removal/cracking) have been used to break seed dormancy in many tropical tree species (Oboho and Ogana, 2012). The use of acid is restricted especially with its handling and cost. Seed coat cracking is laborious and time consuming. This difficulty observed during germination of hard coated seeds tree species in nursery is a fundamental challenge in their utilization for reforestation and afforestation exercise. Therefore, it is expedient to understand the temperature requirement that favours dormancy removal from seeds of selected urban tree species. *Delonix regia* (Plate 1), *Polyalthia longifolia* (Plate 2), *Terminalia mantaly* (Plate 3), and *Senna siamea* (Plate 4), are majorly used species because of their aesthetics value. However, inadequate information exists on the germination and propagation methods of these four urban tree species for professional planner and management of our urban space and environment. The utilization of soaking treatment for enhanced seed germination of selected urban tree species was carried out to provide information to urban foresters on the suitable dormancy treatment to adopt during nursery operations.

Plate 1. Denolix rigea

Plate 2. Polyalthia longifolia

Plate 3. Terminalia mantaly

Plate 4. Senna siemea

2. MATERIALS AND METHODS

2.1 Study Area

Experiment was conducted in the laboratory of Science Laboratory Technology of Delta State University, Abraka. Delta State lies at latitude 5˚00' and 6˚30' North and longitude 5˚00' and 6˚45' and the study site latitude 6˚7'42" and 6˚7'43" North and longitude 5˚47'51" and 5˚47'51" East.

2.2 Seed Collection

Seeds of *Terminalia mantaly, Senna siamea, Delonix regia* and *Polyalthia longifolia* were procured from the Forestry Research Institute (FRIN) Ibadan Oyo State, Nigeria.

2.2.1 Procedure

Morphologically similar and viable seeds were selected and used for the study. The seeds were counted by hand The seed weight was determined according to International Seed Testing Association (Hampton, 1993) method. Seventy-two (72) seeds were weighed for 3 replications separately. The 72 seeds were selected randomly for each treatment (cold water, warm water, hot water and control). The planting top soil was thoroughly mixed and sieved to get a uniform soil mixture for the seedlings. Polythene pots of size 12cm x 24cm was filled with soil and the seeds sown at the rate of two seeds per pot at 5cm depth.

2.3 Data Collection

Data on first day emergence and number of germinated seeds were collected to calculate seedling germination rate in comparison with the control and treatments. The seedling germination rate was measured within and between the four species. A seed is considered to have germinated when the tip of the radical emerges free from the coat (Wiese & Binning, 2012).

2.4 Pre-germination Experiments

2.4.1 Procedure

Seventy-two (72) healthy morphologically similar seeds of four tree species were subjected to three varying water temperature experiments (1) Cold-water (2) Warm-water (3) Hot-water and (4) control. Twenty-four (24) seeds each for temperature, warm and hot water were soaked in Thermostat water bath (Plate 5) and Polyethylene Terephthalate bottles (PET) for cold water. The control was not soaked.

2.4.2 Experiment: effect of varying water temperature and soaking duration on the germination rate and germination percentage of seeds of man

Twenty-four (24) seeds each of the four tree species were placed in 4 PET bottles each, 6 seeds per bottle, and soaked in Cold-water (12^0C) with soaking time (24hrs, 48hrs, 72hrs and 0hrs), Warm-water (40^oC) at (5mins, 10mins, 15mins and 0mins) and Hot-water at 100^oC at varying soaking time (30secs, 60secs, 90secs and 0secs).

Plate 5. Thermostat water bath

- Followed by the gradual removal of seeds according to soaking time, which was transferred and sown at a depth of 5cm in already prepared poly pot filled with 2kg top soil at 2 seeds per poly pot and replicated 3 times.
- This was followed by daily monitoring to record emerged seedlings.
- Watering was done daily at fifteen centi liters per poly pot.

Table 1. Germination parameters and method of collection

S/N	Parameters	Instruments
1	First day emergence	Visual observation
2	Number of germinated seeds	Visual observation
3	Percentage germination	Germination % = Number of germinated seed/ Number of seeds sown X 100

Plate 6. Nursery site of the department of forestry and wildlife

2.5 Data Collection

Data on the parameters and method of collection is as shown in the Table 1;

2.6 Experimental Design

For the laboratory experiment, completely randomized design was used. The pot experiment was carried out in the Nursery site (Plate 6) of the Department of Forestry and Wildlife and laid out using a 4 X 4 factorial experiment in Randomized Complete Block Randomized Design (RCBD) with the model below

$$Y_{i,j,k} = Ц + B_i + P_j + T_k + PT_{jk} + e_{i,j,k}$$

Where,

Y_{ijk} = Individual observations
Ц = Overall mean
B_i = Effect of blocks (or replicates)
P_j = Effect of Plants
T_k= Effects of treatments (Temperature/Soaking duration)
PT_{jk} = Effects of interactions PT
e_{ijk} = Experimental error

A total of 288 seedlings were planted for *Terminalia mantaly, Senna siamea, Delonix regia* and *Polyalthia longifolia* respectively. The Experiments lasted for 44 days (12th of June to 25th July 2023).

2.7 Data Analysis

Germination assessment and growth parameters of seedlings was subjected to analysis of variance (ANOVA) using SAS to statistically verify the significant difference of effects of treatment and soaking period on the seed's germination at 95 percent confidence level.

3. RESULTS AND DISCUSSION

3.1 Effect of Cold-water on Sprout and Germination of Seeds of Selected Trees Species

The effects of cold-water (12^0C) on the germination of seeds of the four urban trees presented in Table 2 were not significant. Seeds of *Senna siamea* soaked for 72hours had the earliest days to germinate (8±0.85) and sprout (11.33±0.85) while those of *Terminalia mantaly* and *Polyalthia longifolia* soaked for 24 hours had the highest days (19.33±0.85 and 22.50±0.85) to

germinate and sprout respectively. The interaction effects of the four selected urban tree seeds and the soaking duration were not significant for germination and sprouting. Seeds of *Senna siamea* soaked for 24 and 48 hours both germinated and sprouted within 4 days and 7 days after sowing respectively (Fig. 1). *Terminalia mantaly* seeds without soaking (control) had the longest days-16 and 24 to germinate and sprout respectively (Fig. 1). One seed each of *Senna siamea* soaked for 24 and 48 hours germinated at day 4 after sowing (Fig. 2).

Usman, et al*.,* (2010) observed that no significant difference existed in sprout of *Acacia senegal* seeds soaked in cold-water at room temperature for 8, 12 and 24 hours respectively. Amusa (2011) also reported that there was no significant difference in seeds of *Afzelia africana* (Sm. ex Pers) treated with cold-water at 1, 12 and 24 hours as with *A. africana* seeds treated with hot water and sulphuric acid. Nikhil et al*.,* (2024) reported that seed germination of *Mimusops elengi* L., (bullet wood) soaked in cold-water for 24 hours enhanced seed germination. Seed dormancy of *Polyalthia longifolia, Terminalia mantaly, Senna siamea* and *Delonix regia* can be easily broken when soaked in cold-water for 42 hours. Odoi et al*.*, (2019) observed that dormancy in seeds of *Maesopsis eminii* and *Terminalia catappa* was broken when soaked for 12-24 hours in cold-water. The above report by various authors corroborated our findings in this study.

All seeds of the four selected trees treated with cold water had 100 percent germination rate (Fig. 3). Seeds of *Senna siamea* and *Delonix regia* had 66.7% and 58.3 % germination percentage respectively at week 2. This shows that cold water enhances the germination and sprout of seeds of *Polyalthia longifolia, Terminalia mantaly, Senna siamea* and *Delonix regia*. Authors (Odoi et al., 2019; Billah et al*.,* 2015) observed that pre-germination treatment of seeds enhances seed germination and sprout. Tree seeds pre-germination treatment studies conducted by a number of researchers have shown that pre-sowing treatments significantly increase seed germination rates. Jothy et al., (2013) reported that *Polyalthia longifolia* and *Terminalia mantaly,* propagated by seeds, germinated between 1-6 weeks of planting which is in line with the findings of this study. All the reports underscore the importance of pre-germination treatment to break seed dormancy as also evident in our study.

Table 2. Effects of cold-water (12˚C) soaking on the germination and sprout of each of the selected species

Tree species	Hours	Germination (days)	Sprout (days)
Polyalthia longifolia			
	0	11.33d	13.33c
	24	18.50a	22.50a
	48	14.00c	16.50b
	72	18.00b	21.00a
Terminalia mantaly			
	0	17.33a	19.67b
	24	19.33a	22.33a
	48	12.67b	14.67c
	72	11.00c	12.33d
Senna siamea			
	0	13.67a	16.67a
	24	13.33a	16.33a
	48	12.67a	15.00b
	72	8.00b	11.33c
Delonix regia			
	0	13.33b	16.00b
	24	11.67d	14.33d
	48	12.67c	14.67c
	72	17.33a	20.00a
LSD (0.05)		2.37	2.38
SE		0.85	0.85

N.B.: Mean with the same alphabet is not significantly different from each other

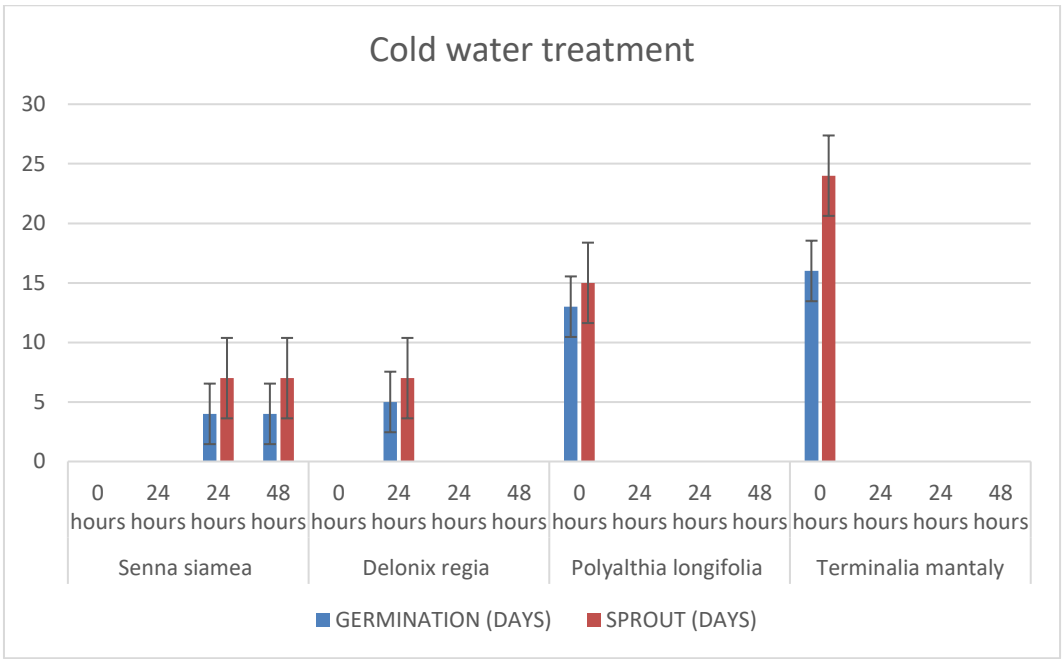

Fig. 1. Germination and sprout in days of seeds of the selected urban trees soaked in cold-water

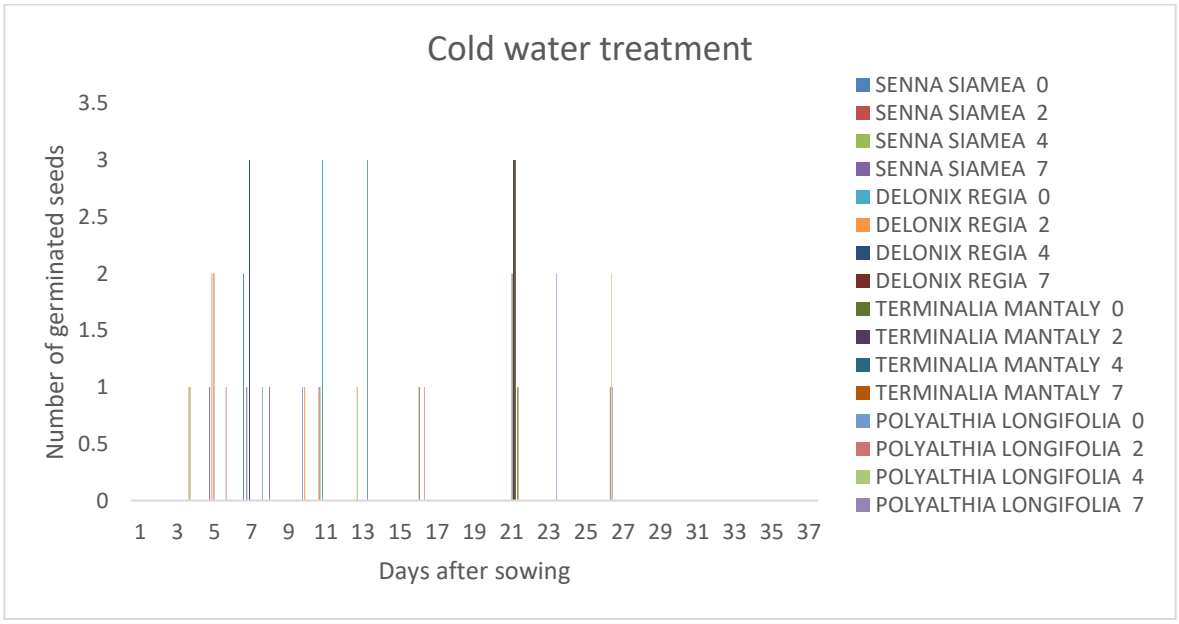

Fig. 2. Number of germinated seeds in days of tree species soaked in cold-water

3.2 Effect of Hot-water Treatment on Germination and Sprout of Seeds of Selected Trees

The effect of hot-water treatment on the germination and sprout of seeds of the four urban trees presented in Table 3 was significant ($P< 0.05$). Seeds of *Senna siamea* soaked for 90 seconds and *Delonix regia* soaked for 60 seconds had the earliest days (6.00±2.99) to germinate while seeds of *Polyalthia longifolia* soaked for 30 seconds had the longest days (41.00±2.83) to sprout (Table 3). However, soaking duration in hot water significantly ($P<0.05$) influenced the sprout of seeds. Seeds soaked for 60 seconds in hot water sprouted early with an average of 13.56±0.71 days. The control took longer time (20.92±0.71) to sprout (Table 3). The effect of interaction of seeds of the four selected urban trees and soaking duration in

hot-water was not significant for germinate, however, for sprout, the interaction effects were significant (P<0.05). Seeds of *Senna siamea* soaked for 60 seconds and *Delonix regia* soaked for 30 seconds germinated and sprouted within 5 and 8 days after planting respectively (Fig. 4). *Polyalthia longifolia* seeds soaked in hot-water for 30 seconds took the longest days of 23 and 25 to germinate and sprout respectively (Fig. 4). One seed each of *Senna siamea* soaked for 60 and 90 seconds and *Delonix regia* soaked for 30 and 60 seconds germinated at day 5 after sowing (Fig. 5). One hundred germination percent was observed for seeds of the selected urban trees soaked in hot-water at varying soaking duration by week 7 (Fig. 6). Seeds of the selected trees soaked in hot-water all had 41.7% germination rate at week 2. Seeds of *Senna siamea* had 91.7% germination at weeks 2 while *Polyalthia longifolia* had 41.7% germination rate at week 6 (Fig. 6).

The report by Amusa (2011), who observed unfavourable sprout and germination in *Afzelia africana* soaked in hot water (100^{o}C) for 1, 12 and 24 hours, confirmed our findings on hot-water pre-treatment. The study by Sharma et al*.,* (2020) who observed that seeds of *Albizzia lebbeck* and *Peltophorum pterocarpum* soaked in hot-water for 60 seconds attained satisfactory germination (94 and 97% respectively) lend credence to our findings in this study. Ogungbesan et al*.,* (2017) reported that seeds of *Cassia siamea* L. soaked in hot-water (100^{o}C) for 12 minutes recorded 100 percent germination rate compared to seeds soaked for 24, 36, 48 and 60 hours as also reported in our study. Abdulazeez, (2016) observed that seeds dormancy of *Senna obtusifolia* from Bichi, Nigeria, was broken when soaked in hot-water (100^{o}C) for 2 to 20 minutes within 3 days of sprouting after sowing and 100 percent germination rate as confirmed in this study. Sodimu et al*.,* (2023) observed that pre-sowing treatment with hot-water (100^{o}C) for 0, 15, 30, 60, 90 and 150 seconds significantly influenced final germination percentage of *Faidherbia albida* (Delile) A. Chev. seeds in Kaduna, Nigeria which corroborates our earlier findings. Sodimu et al. (2023) recommended pre-germination treatment of seeds of *F. albida* (Delile) A. Chev soaked in hot-water (100^{o}C) for 15 and 20 seconds for nursery establishment. Odoi et al., (2019) reported that soaking period and water temperature significantly influenced seedling vigor of forest trees. The above findings are a testament of the effectiveness of soaking in hot water.

Table 3. Effects of hot-water (100^{o}C) soaking on the germination and sprout of each of the selected species

Tree species	Seconds	Germination (Days)	Sprout (Days)
Polyalthia longifolia			
	0	32.00a	36.67a
	30	37.50a	41.00a
	60	20.00b	36.50a
	90	29.33a	40.00a
Terminalia mantaly			
	0	21.00b	24.67b
	30	21.00b	24.67b
	60	21.33b	24.67b
	90	38.00a	39.00a
Senna siamea			
	0	6.67a	8.67a
	30	7.67a	9.00a
	60	6.33a	8.33a
	90	6.00a	7.67a
Delonix regia			
	0	10.33a	13.67a
	30	7.67a	12.67a
	60	6.00a	7.67a
	90	6.33a	8.00a
LSD (0.05)		8.38	7.91
SE		2.99	2.82

N.B.: Mean with the same alphabet is not significantly different from each other

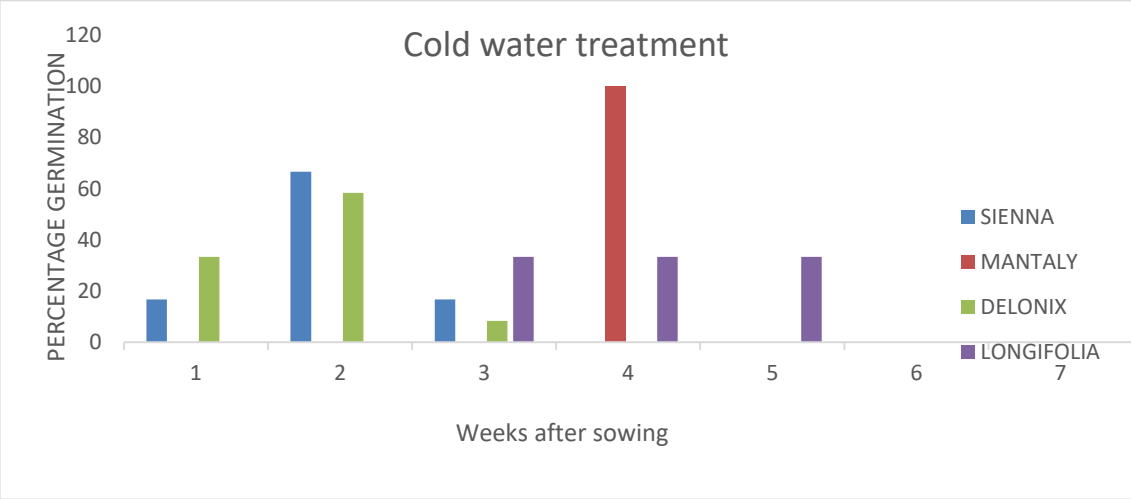

Fig. 3. Percentage germination of seeds of tree species

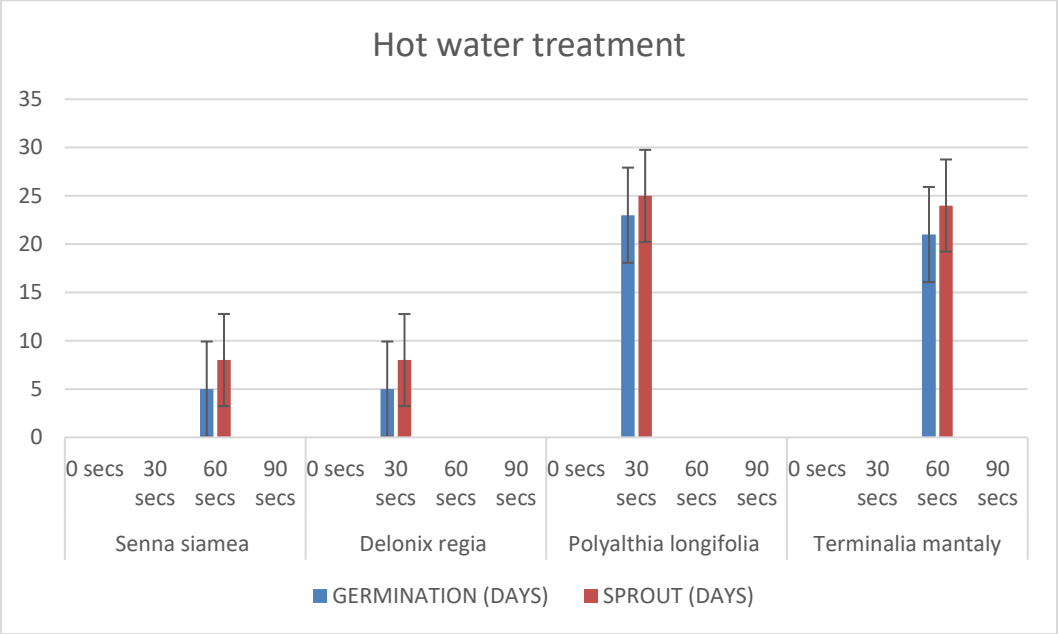

Fig. 4. Germination and sprout in days of seeds of the selected urban trees soaked in Hot-water

3.3 Effect of Warm-Water Treatment on Germination and Sprout of Seeds of Selected Urban Trees

The effect of warm-water treatment on germination and sprout of seeds of the four urban trees presented in Tables 4 was significant ($P < 0.05$). Seeds of *Senna siamea* soaked for 10 and 5 minutes had the earliest days to germinate (5.00±2.22) and sprout (8.00±2.14) respectively. Seeds of *Delonix regia* soaked for 10 minutes germinated within 4 days of sowing and sprouted 8 days after planting, while for control, seeds of *Polyalthia longifolia* germinated and sprouted within 21 and 25 days after sowing respectively (Fig. 7). One, three and one seed each of *Senna siamea* soaked for 5, 10 and 15 minutes germinated at day 5 after sowing (Fig. 8) One hundred percent germination was recorded for seeds of the selected urban trees soaked in warmwater at varying soaking duration (Fig. 9). At week 2, seeds of the urban trees soaked for 0minutes and 15 minutes had 50.0% germination percent while seeds of *Senna siamea* and *Delonix regia* had 91.7% germination.

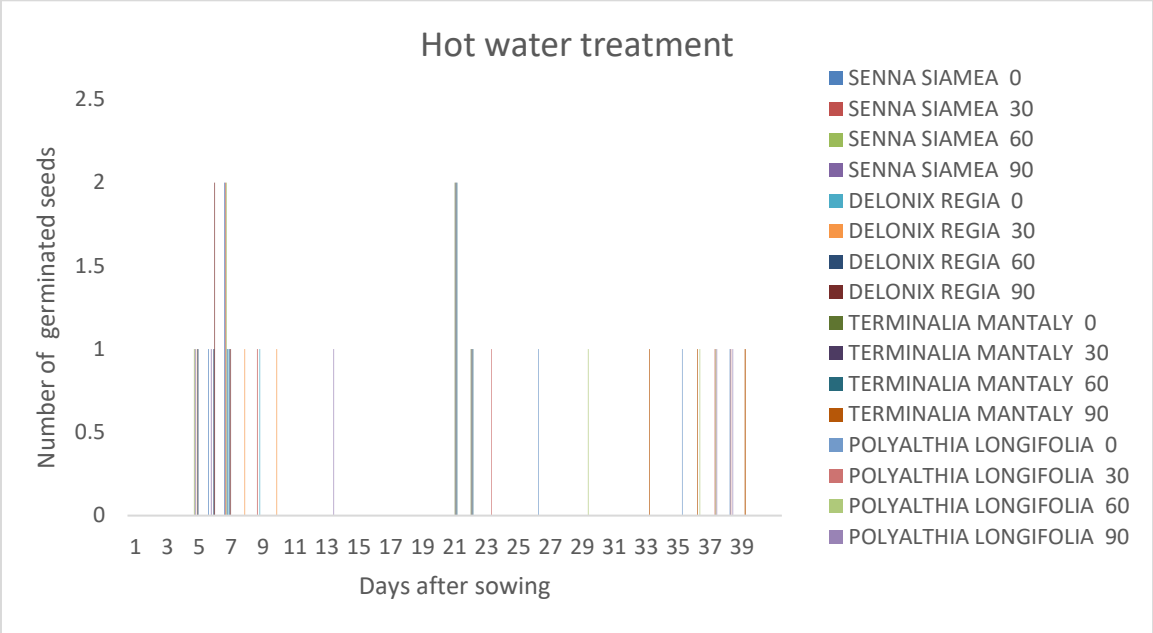

Fig. 5. Number of germinated seeds in days of each tree species soaked in hot-water

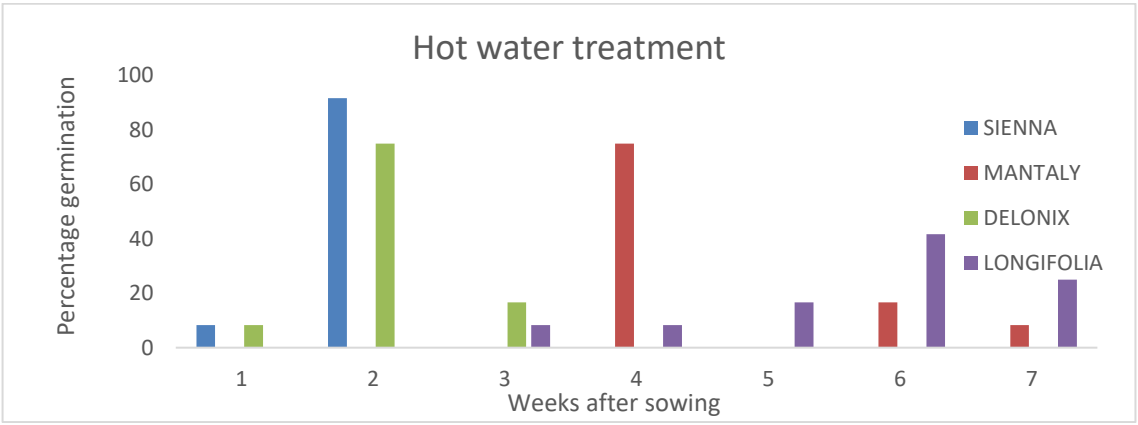

Fig. 6. Germination percentage of seed of tree species in hot-water

Doody and O'Relly, (2008) examined effect of varying temperature (20^{0}C, 22^{0}C, 25^{0}C, 27^{0}C, 30^{0}C, 32^{0}C, 35^{0}C, and 37^{0}C) on germination of seed of *Jathropha curcas*. The germination percentage at varying temperatures differs significantly (P<0.0001). The highest germination recorded was at 35^{o}C which corroborated our earlier findings in this study. Hanif et al*.,* (2019) observed significant differences in germination of seeds of *Vigna radiata* L. Wilczek soaked in water at 10^{0}C, 20^{0}C and 30^{0}C. Hanif et al., (2019) observed high emergence for seeds of *Vigna radiata* soaked at 30°C in water. Saleem et al*.,* (2014) reported early emergence (6.28 days) and higher germination rate in bitter gourd cultivars seeds soaked in water. Guo et al*.,* (2024) reported that seeds of *Lilium concolor* var. megalanthum soaked in water at 25°C were significantly higher in terms of germination percentage when compared to other temperatures (10°C, 15°C, 20°C, 25°C). Zhang et al*.,* (2015) reported that seeds of litchi cultivars soaked in water (37-44^{0}C) had a better germination performance (90%) in comparison with seeds not soaked. Luo et al*.,* (2022) observed a higher germination rate for seeds of *Betula platyphylla* Suk soaked at 25^{0}C and 30^{0}C relative to those soaked at 15^{0}C and 20^{0}C. Odoi et al. (2019) observed that soaking period and water temperature greatly impacted seed germination (90.0% for *Terminalia catappa* and 85.0% for *Maesopsi seminii*. Masilamani et al., (2013) reported a high germination rate of 80.0 - 98.0% and 98.0% for seeds of *Terminalia*

cattapa sowed without and with pre-germination treatment respectively. The above findings corroborate the results for warm water pre-treatment observed in this study (Van, 2010).

Table 4. Effects of warm-water (40ºC) soaking on the germination and sprout of each of the selected species

Tree species	Minutes	Germinate (days)	Sprout (days)
Polyalthia longifolia			
	0	23.00a	26.67b
	5	29.00a	34.67a
	10	22.33b	26.00c
	15	25.00a	28.33b
Terminalia mantaly			
	0	21.67a	24.67a
	5	22.00a	25.33a
	10	22.33a	26.33a
	15	24.67a	29.33a
Senna siamea			
	0	8.33a	12.67a
	5	6.00a	8.00a
	10	5.00a	8.33a
	15	6.33a	10.00a
Delonix regia			
	0	7.33a	9.67a
	5	10.00a	12.33a
	10	7.00a	11.00a
	15	8.00a	10.00a
LSD (0.05)		6.22	6.00
SE		2.22	2.14

N.B.: Mean with the same alphabet is not significantly different from each other

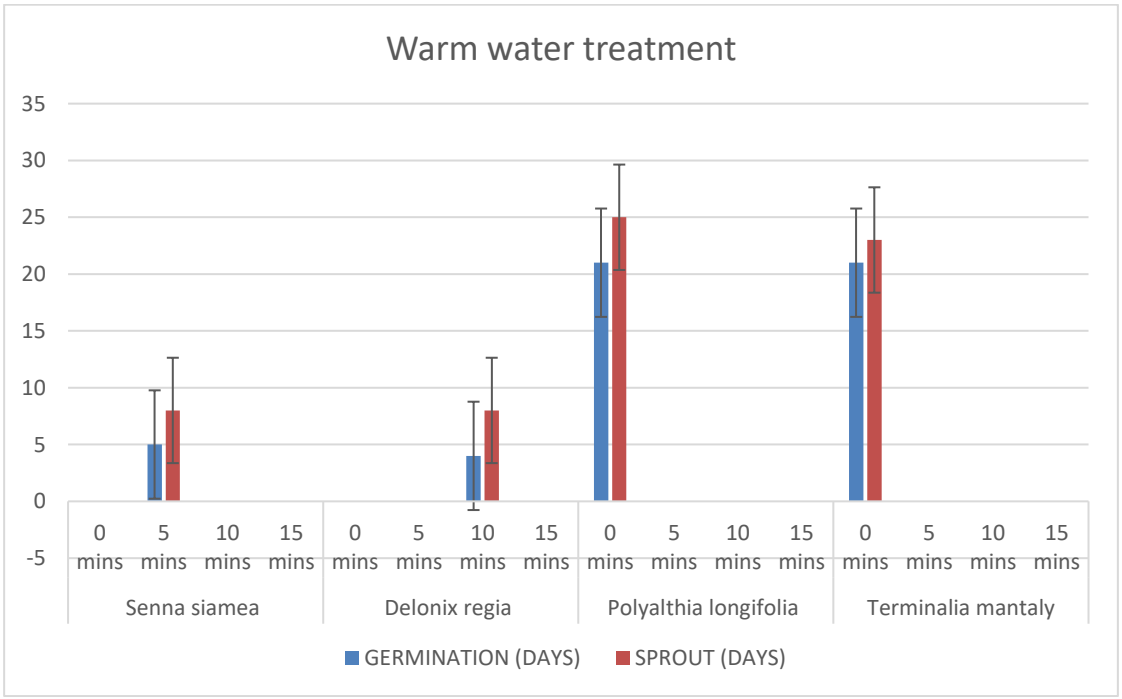

Fig. 7. Germination and sprout of seeds of the selected urban trees soaked in warm-water

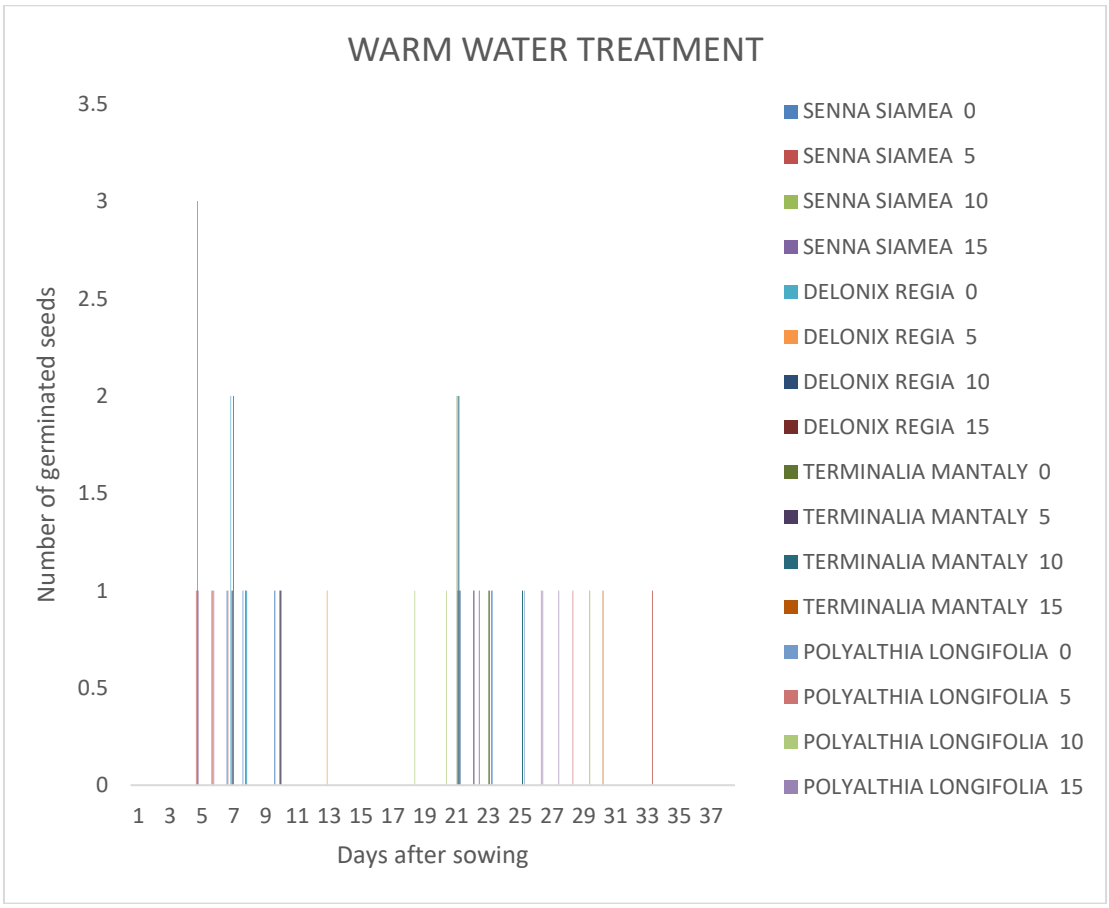

Fig. 8. Germination percentage of warm-water experiment

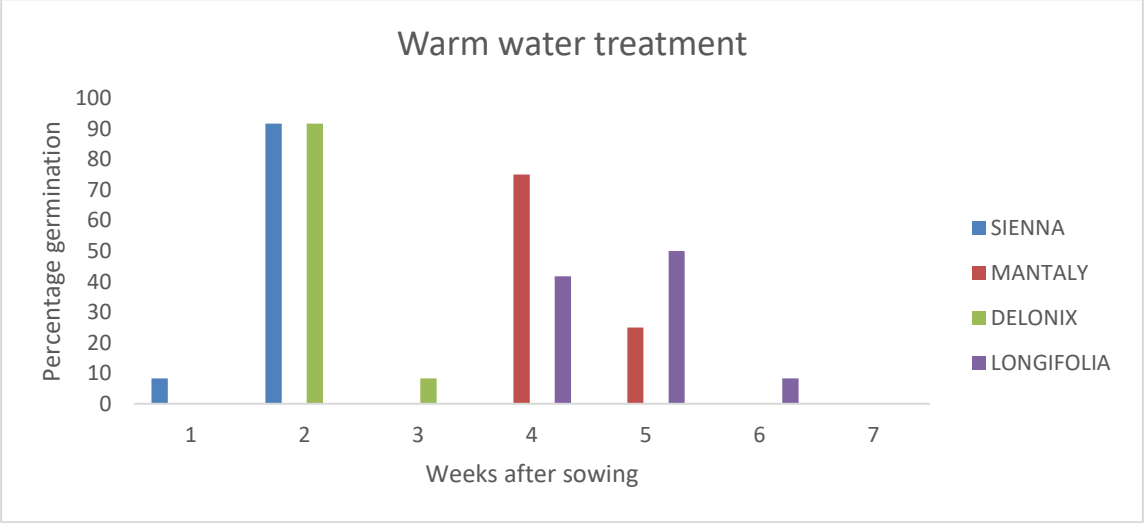

Fig. 9. Number of germinated seeds of selected urban tree species soaked in warm water

4. CONCLUSION

Seed pretreatment contributed positively to the germination of the study species; it is therefore advised that seed pretreatment of tropical trees in these media is needed to break seed dormancy and quicken germination. Seed coat cracking is laborious and time consuming. This difficulty observed during germination of hard coated seeds tree species in nursery is a

fundamental challenge in their utilization for reforestation and afforestation exercise. Therefore, it is expedient to understand the temperature requirement that favours dormancy removal from seeds of selected urban tree species.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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