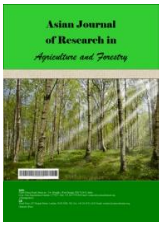


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# The Effect of Seed Source and Pre-sowing Treatment on Germination of *Canarium schweinfurthii* [Engl] Seeds

**E. L. Anozie[1*] and E. G. Oboho[2]**

[1]*Department of Forestry and Wildlife Management, Nnamdi Azikiwe University, Awka, Nigeria.*
[2]*Department of Forest Resources and Wildlife Management, University of Benin, Benin-City, Nigeria.*

***Authors' contributions***

*This work was carried out between the two authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

This study examined the effect of seed source and pre-sowing treatment on germination of *Canarium schweinfurthii* [Engl] seeds. The seeds were sourced from Unubi in Anambra state (T1) and Jos in Plateau state (T2) in Nigeria. The experiment was conducted at the University of Benin and lasted for 14 weeks. It was laid out in a completely randomized design (CRD) pattern using 2x7 factorial combinations of 2 sources and 7 pre-sowing treatments.

The pre-sowing treatments were complete removal of seed coat (CR), partial cracking (PC), burning under dry grass (BG), 70% $H_2SO4$ (7H), 80% $H_2SO4$ (8H), 3 days (72 hours) soaking in water (SW) and control (CT). Germination parameters investigated were days to germination, germination percentage, germination energy, germination period and germination value. Data collected were subjected to Analysis of variance (ANOVA) at 5% significance and significant means were separated using LSD. There was no significant difference in the mean days to germination (20.7 days in T1 and 21 days for T2) and mean germination percentages (31.14% in T1 and 31.71% for T2) of the sources. The treatments days to germination were significantly different with

**Corresponding author: E-mail: ebereloretto@gmail.com;*

CR being the first to germinate (12 days) while 7H germinated last (41 days). There was significant difference in the mean germination period (31.71 days in T1 and 23.57 days for T2), germination energy (1.24 in T1 and 2.38 for T2) and germination values (0.3 in T1 and 0.54 for T2) in the investigated sources, while the mean germination percentages of the pre-sowing treatments irrespective of source were significantly different. Treatments BG had the best mean germination percentage followed by treatment SW and CT while 8H had the poorest.

It is therefore recommended that treatment BG is the best followed by SW for increase in germination percentage. But where seedlings are needed in little quantity within a short time, treatments CR and PC are recommended. Acid treatment is unsuitable for the seeds of *Canarium schweinfurthii*.

*Keywords: Canarium schweinfurthii; dormancy; germination; pre-sowing treatments; seed source.*

## 1. INTRODUCTION

The rapid rate of forest loss and degradation across the tropics has continued to increase both the fragmentation of many populations and the risk of plant extinction. In Nigeria as elsewhere, conservation of forest genetic resources is achieved through their protection in natural habitat (*in- situ*) or preservation of samples of the genetic diversity of endangered species away from their habitats (*ex-situ*) in facilities such as botanical gardens, seed gene banks, *in-vitro* gene banks, and field gene banks [1]. *Canarium schweinfurthii* Engl (African elemi) is a forest tree from the Burceraceae family whose geographical distribution is widely spread throughout Africa [2,3]. It is called ‘Atili’ in Hausa,’ Ube mgba’ or’ Ube okpoko’in Igbo, ‘Origbo or Elemi’ in Yoruba [4] and in English, it is also called Torchwood, frankincense, incense tree family, Black olive, Bush candle tree or Forest pear. The fruit is common in Bauchi, Southern Kaduna, Niger, Oyo and Plateau States of Nigeria, is commonly found in large quantity in Pankshin, Plateau State of Nigeria [5] and is also produced in similar quantities in other states of the South-Eastern Nigeria including Enugu, Ebonyi and Anambra states.

The fruit is a small drupe, greenish when unripe and bluish-purple when ripe, glabrous, 3-4 cm long and 1-2 cm thick (Plate 1a) [5]. The fruit contains a hard spindle-shaped, trigonous stone seed coat (Plate 1b) that eventually splits releasing seeds, mainly 2 or 3 seeds (Plate 1c) [4]. The fruit can be eaten raw or soften in warm water to improve palatability [6] and eaten like that of *Dacryodes edulis* (local pear). The tree grows wild in forests and common land. Local people gather the fruits which have a ready market. Other benefits derived from *Canarium schweinfurthii* includes, fuelwood, timber, gum and resins, medicine. The seeds are also used as a flooring material for decoration and arithmetic counters in schools. Despite the apparent economic importance of *Canarium schweinfurthii* in Nigeria, the existence of this species is threatened by increased deforestation, urbanization and other infrastructural developments. The growth of any tree begins with the germination of its most important propagule, the seed [7]. Lots of seeds are lost annually due to low germination status after free fruit fall from the mother tree; the seed coat dormancy being partly responsible, thereby threatening the existence of the species. The fruit being used as food also reduces what should have been available in the forest seed store for natural regeneration. There is need to test different pre-sowing treatments that would break the seed dormancy and ensure quick and uniform germination of this species. The aim of this investigation was to assess the effect of seed source and different pre-sowing treatments on germination of *Canarium schweinfurthii* seeds.


**Plate 1a. Ripe fruits of *Canarium schweinfurthii***

**Plate 1b. Seeds of *Canarium schweinfurthii***

**Plate 1c. Decoated seed of *Canarium schweinfurthii***

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The experiment was carried out in the screen house of Crop Science Department, Faculty of Agriculture, University of Benin, Benin City, Edo State of Nigeria. The GPS location of the screen house is Latitude 6º33$^1$N and Longitude 5º37$^1$E with an elevation of 152.4 m above the sea level. Benin City is in the rainforest zone with a bimodal rainfall pattern, with a mean rainfall of 2,300 mm per annum and mean temperature of 25.1ºC [8].

### 2.2 Seed Procurement and Preparation

Mature ripe fruits of *Canarium schweinfurthii* were gathered from a phenotypically superior mother tree in Unubi ($T_1$) in Anambra State and Jos ($T_2$) in Plateau State. After procurement, the fruits were tied in a nylon bag and kept for five days in order to allow the fruit pulp to ferment and soften for easy extraction of the seeds. A total number of 840 seeds, 420 seeds from each of the two sources were sown. The weights of the fruits and seeds were determined using electronic weighing balance. The average weight of a fruit from Jos was 6.01 g while Anambra was 5.6 g, Also the average weight of a seed from Jos was 4.1 g while Anambra was 3.5 g.

### 2.3 Experimental Design and Treatments

Completely randomized design (CRD) was used in the study. There were 14 treatments made up from factorial combinations of 2 seed sources (Anambra and Jos) and 7 pre-sowing treatments.

The pre-sowing treatments were;

i. Control (CT)
ii. Complete seed coat removal (CR)
iii. Partial cracking of seeds (PC)
iv. Soaking of seeds in cold water for 3 days (72 hours) (SW)
v. Light burning of the seeds under dry grass (BG)
vi. Treatment of seeds with 70% sulphuric acid for 5 mins (7H)
vii. Treatment of seeds with 80% sulphuric acid for 5 mins (8H).

### 2.4 Data Collection

Data was collected based on germination assessment. Germinated seeds were counted and recorded from the date of first germination until there was no more germination. A seed was considered to have germinated when the tip of the radicle emerges free from the seed coat [9,10].

The germination parameters investigated included;

i Days to germination
ii Number germinated
iii Germination percentage
iv Germination trend
v Germination energy
vi Germination value.

Data collected were subjected to Analysis of variance (ANOVA) using SAS software package version 9.0 [11]. Means were separated by LSD (least significant figure) test at 5% level of probability.

## 3. RESULTS

### 3.1 Germination

The type of germination exhibited by *Canarium schweinfurthii* seeds was epigeal germination (Plates 2a-2d) of the phanerocotylar type. The new seedlings emerged with the hypocotyle forming a hook like structure through the soil surface (Plate 2a). The hook remained buried in the soil for 5 days. Between 5-8 days, the cotyledons being exhausted of nutrients gradually drops the seed coat (Plate 2b) and the cotyledons were exposed as digitate leaves which were greenish yellow at first and later turned green (Plate 2c and 2d). The mean days to germination were 20.7 days in $T_1$ and 21 days for $T_2$. There was no significant difference between values of days to germination in the investigated sources. The seedling germination time varied with pre-sowing treatments in both $T_1$ and $T_2$ sources. The first six weeks after seed germination was the most active germination period for all the treatments and sources after which there was decline to very scanty, irregular weekly germination. Treatments CR and PC in both sources attained their most active germination periods within fourteen days. Germination details are presented on Tables 1 and 2.

Germination commenced in treatment CR for both sources on the 12th day after sowing (DAS). This was followed by treatment PC germinating 16 and 14 days after sowing for $T_1$ and $T_2$ sources respectively. For $T_1$, it took 12, 16, 22, 37, 24 and 34 days after sowing (DAS) for germination to commence in CR, PC, BG, 7H, SW and CT, respectively, while $T_2$ took 12, 14, 20, 45, 23 and 33 in CR, PC, BG, 7H, SW and CT. There was no germination in treatment 8H in both seed sources.

### 3.2 Germination Trend

Germination trend for *Canarium schweinfurthii* seeds was irregular and intermittent irrespective of seed source and the time of attainment of peak germination varied between treatments. For source $T_1$, treatments CR, PC, BG, 7H, SW and CT attained peak germination in 2, 3, 8, 6, 10 and 12 weeks after sowing, respectively (Fig. 1). For source $T_2$, it took CR, PC, BG, 7H, SW and CT the time of 2, 4, 7, 7, 9 and 6 weeks after sowing to attain peak germination respectively (Fig. 2). There was a great disparity (6 weeks) between the time of attainment of peak germination for $T_1$ and $T_2$.

### 3.3 Germination Period (GP)

The germination period (GP), which is the period from the first day of germination to the last day of germination ranged between 5 and 92 days for both seed sources. For treatments BG, 7H, SW and CT, it ranged between 20-50 days after germination (DAG). Generally, irrespective of the source, the germination period of CR and PC treatments was between 5-16 days; but those of CT took 49 and 92 days for sources $T_2$ and $T_1$ respectively (Table 1). For it took $T_1$ 6, 11, 40, 22, 52, 92 days to complete their germination in CR, PC, BG, 7H, SW and CT respectively. Also for $T_2$, it took 5, 16, 36, 15, 44, and 49 days for CR, PC, BG, 7H, SW and CT respectively to complete their germination. There was a great disparity (43 days) between the germination periods for treatment CT in $T_1$ and $T_2$. The $T_2$ source had mean germination period of 23.6 days while that of $T_1$ was 31.7 days. Germination periods for the two sources were significantly different (Table 2).

**Plate 2a. The new seedlings emerged with the hypocotyle forming a hook like structure through the soil surface**

**Plate 2b. The cotyledons gradually drops the seed coat**

2c

2d

**Plates 2c and 2d. The cotyledons were exposed as digitate leaves**

**Plate 2a-2d. Stages in the germination of *Canarium schweinfurthii* seeds**

**Table 1. Germination Parameters of *Canarium schweinfurthii* in relation to sources and treatments**

| Treatments | Days to germination | | Germination period (GP) | | Germination percentage (%) | |
|---|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_1$ | $T_2$ | $T_1$ | $T_2$ |
| CR | 12 | 12 | 6 | 5 | 13 | 6 |
| PC | 16 | 14 | 11 | 16 | 15 | 28 |
| BG | 22 | 20 | 40 | 36 | 63 | 66 |
| 8H | - | - | - | - | 0 | 0 |
| 7H | 37 | 45 | 21 | 15 | 16 | 8 |
| SW | 24 | 23 | 52 | 44 | 61 | 63 |
| CT | 34 | 33 | 92 | 49 | 50 | 51 |

**Table 2. Germination parameters of *Canarium schweinfurthii* in relation to sources and treatments**

| Source (S) | Days to germination | Germination percentage (G%) | Germination energy (GE) | Germination period (GP) | Germination value (GV) |
|---|---|---|---|---|---|
| Unubi($T_1$) | 20.71 | 31.14 | $1.24^{b}$ | $31.71^{a}$ | $0.37^{b}$ |
| Jos($T_2$) | 21.00 | 31.71 | $2.38^{a}$ | $23.57^{b}$ | $0.54^{a}$ |
| LSD | 5.962 | 6.541 | 0.795 | 8.260 | 0.148 |
| Sig | ns | ns | ** | ** | ** |
| **Pre-sowing trt (P)** | | | | | |
| CR | $12.00^{bc}$ | $9.50^{b}$ | $1.00^{c}$ | $5.50^{bc}$ | $0.05^{bc}$ |
| PC | $15.00^{bc}$ | $21.50^{b}$ | $1.10^{c}$ | $13.50^{b}$ | $0.19^{b}$ |
| BG | $21.00^{b}$ | $64.33^{a}$ | $4.97^{a}$ | $35.04^{ab}$ | $0.98^{a}$ |
| 8H | $0.00^{c}$ | $0.00^{c}$ | $0.00^{c}$ | $0.00^{c}$ | $0.00^{c}$ |
| 7H | $41.01^{a}$ | $12.00^{b}$ | $1.33^{bc}$ | $17.83^{b}$ | $0.09^{b}$ |
| SW | $23.86^{b}$ | $62.67^{a}$ | $1.83^{b}$ | $48.12^{ab}$ | $0.96^{a}$ |
| CT | $33.79^{a}$ | $50.50^{a}$ | $4.80^{a}$ | $70.50^{a}$ | $0.95^{a}$ |
| LSD | 11.125 | 11.866 | 1.487 | 15.453 | 0.277 |
| Sig | ** | ** | ** | ** | ** |
| Interaction | | | | | |
| S X P | ns | ns | ** | ** | ** |

*Means within columns with different superscript are significantly different*
***= significantly different at P< 0.05; ns= no significantly different at P< 0.05*

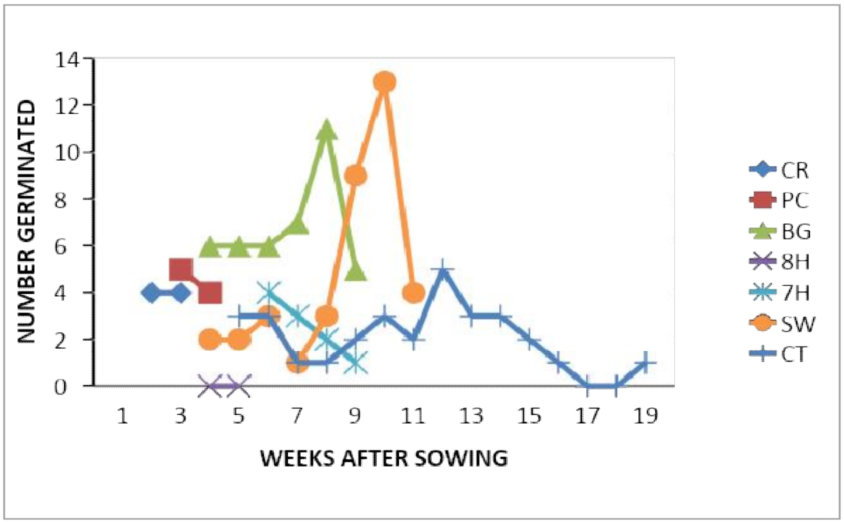


**Fig. 1. Germination trend for source $T_1$ of *Canarium schweinfurthii* underdifferent treatments**

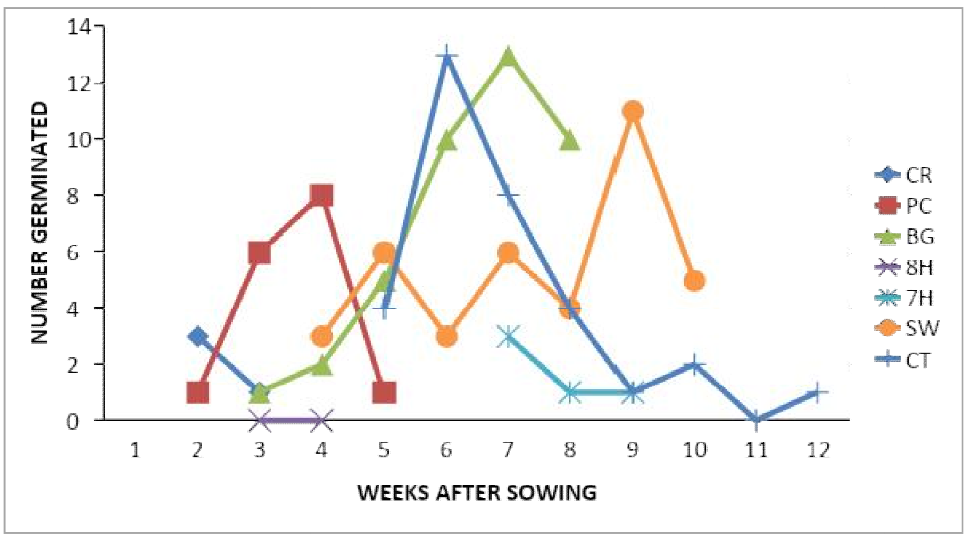


**Fig. 2. Germination trend for source $T_2$ of *Canarium schweinfurthii* under different treatments**

### 3.4 Germination Percentage (G%)

*Canarium schweinfurthii* had low germination percentage irrespective of the source. $T_1$ had mean germination percentage of 31.14%, while $T_2$ was 31.71%. Higher germination percentages were obtained in treatments BG and SW in both sources. The treatment 8H had 0% germination in both $T_l$ and $T_2$ sources. Source $T_1$ had germination percentages of 13, 15, 63, 16, 61 and 50, while $T_2$ source had germination percentage of 6, 28, 66, 8, 63 and 51 for CR, PC, BG, 7H, SW, and CT, respectively (Table 1). There was no significant difference in the germination percentages of the seeds from both sources, but there was significant difference in the germination percentages of the treatments irrespective of source (Table 2).

### 3.5 Germination Energy and Germination Values

The germination energy, which is the percentage of number of seeds in a given seed lot that germinated within a definite period, The range 10-30 days had 25% germination, 31-60 days was 50% while 61 days and above had 75% germination. The 25% germination energy was achieved by treatments CR and 7H in $T_1$ and PC in $T_2$ within a period of 10–30 days. The 50% germination energy was achieved in treatments BG for the two sources and 7H in $T_2$ within the period of 31–60 days while 75% germination energy was achieved by SW and CT in both sources. However, irrespective of the treatments, source $T_1$ had mean germination energy of 1.24%, while $T_2$ had 2.38%. Also, irrespective of source, the treatments had 1, 1.1, 4.97, 1.33, 1.83 and 4.83% germination energy for CR, PC, BG, 7H, SW and CT treatments, respectively. Therefore, treatment BG had the best germination energy. The germination values (were the composite value that combined both germination speed and total germination) were small irrespective of sources and treatments, as source $T_1$ had germination values of 0.37, while $T_2$ had 0.54 germination value. Also, irrespective of the sources, the treatments had germination values of 0.05, 0.19, 0.98, 0.09, 0.96 and 0.95 for treatments CR, PC, BG, 7H, SW and CT, respectively (Table 2). There were significant differences both in the seed sources and the interaction between the pre-sowing treatments in both germination energy and germination values.

## 4. DISCUSSION

*Canarium schweinfurthii* seeds had epigeal germination and an intermittent / irregular germination trend. Treatment CR was the first to germinate irrespective of the source and treatment. This could be as a result of the removal of the physical barrier (hard seed coat) which permitted direct imbibitions of water by the seed embryo to trigger germination. This result supports the findings of Oboho [12] who observed that the decoated seeds of *Gambeya albida* were the earliest to germinate. Treatment 7H germinated last and these could have been as a result of the corrosive and detrimental effect on the seed caused by the use of 70% $H_2SO_4$. The different days to emergence observed with different treatments could be as a result of difference in the degree of effectiveness / impact of different pre-treatment on the seed coat. [13] working on the effect of treatment and seed source on Eastern red cedar seeds in USA found that, there was no significant difference in the days to emergence with the seed source but the effects of pre-sowing treatment was significantly different.

The germination period of seeds from the two sources was significantly different. This difference in the germination period observed in seeds from both sources could have been due to degree of hardness of the seed coat, $T_1$ being harder than $T_2$ (personal observation during cracking of the seeds) and these differences could also be probably linked to variation in genetic status of the seed as noted by Oboho and Adeniyi [14]. The significant difference observed in the pre-sowing treatment implies that each pre-sowing treatment had different degree of effect on the seed.

The mean germination percentages of *Canarium schweinfurthii* seeds from different sources were not significantly different. [15] working on the effect of provenances on seed germination and seedling growth performance of *Tamarindus indica* seeds observed that, there was no significant difference in the germination percentages of the seeds collected from three different locations. Also [14] working on influence of pre-sowing treatments and seed source on germination and early growth of *Dialium guineense* seeds observed that seed sources did not have any significant effect on germination percentage but, pre-sowing treatments did. The results obtained in this study showed that there were significant differences between the germination percentages of seeds subjected to different pre-sowing treatments.

Treatments BG had the highest germination percentage in both sources and this showed that heat supplied to the seeds through the light burning of the seeds under dry grass had the best dormancy breaking effect on the seed coat which led to higher germination percentage in *Canarium schweinfurthii* seeds. [16,17] noted that, heat and smoke released during the passage of fire are considered to be the most important fire cues that break dormancy or promote germination of hard-coated seeds.

This increase in germination percentage of treatment BG corroborates the findings of Oboho [18] who reported that light burning of seeds with woody coats using grass enhances germination in hard seed coat species such as *Tectona grandis, Ziziphus spina-christii, Sclerocarya bierra and Balanites aegyptiaca*. [19] stated that fire may trigger seed germination directly through the opening of serotinous coats or cones by inducing the germination of the dormant soil-stored seed banks. They observed that heat from fire disrupts the water impermeable tissue, allowing water imbibition which typically leads to germination. These probably mean that, heat from the burning of dry grass might have triggered the dormant seed which brought about the cell division and allowing water imbibitions that might have contributed to increase in germination percentage of *Canarium schweinfurthii* seeds treated by BG.

Higher germination percentage was also observed in treatment SW and this could be that the seeds had absorbed enough water that softened the seed coat and activated the embryo to effect or trigger seed germination. [20] noted that the imbibitions of water by seeds help to activate and enlarge the embryo which led to breaking of seed coat, removal of inhibitors and increase in germination percentages. This higher germination percentage observed in the (SW) treatment was in agreement with the reports of [21] who reported that soaking of seeds of *Adansonia digitata* in cold water for 12 and 24 hours resulted in increase in rate of seed germination [18] also stated that soaking of seeds of *Adansonia digitata* in water increased germination percentage by 20% and reduced days to germination from 43 days to 24 days. [22] reported that soaking of *Azadirachta indica* seeds in cold water for 1 to 12 hours resulted in increasing rate of seed germination. [23] also observed that soaking of seeds in water helps in softening the seed coats, removal of inhibitors and reduces required time for germination and enhances germination percentage in *Acacia catechu* seeds. However, this is not in agreement with [24] who observed that soaking seeds in cold water reduced the germination of *Afzelia africana* seeds due to oxygen deficiency. This result was contrary to the views of Rasebeka [25] who reported that seeds soaked in cold water showed the lowest germination percentages in Acacia species. This implies that different seed species had varying rates at which their seed coat was permeable to water and gases [22].

Untreated (i.e Control CT) seeds had moderate germination percentage for seeds from both sources. This is an indication that *Canarium* seeds will germinate without treatment but at a much lower rate.

The complete removal of seed coat (CR) treatment was the first to germinate but with low mean germination percentage (9.5%) irrespective of the source. This low germination could be attributed to a possible detrimental effect of the removal of the seed coat that provides protection to the embryo during germination and early growth. The author in this study observed ants and rodents feeding on the cotyledons of this crop in treatment CR upon germination. Oboho [12] similarly reported that the seed coat treatment affected germination date of *Gambeya albida* seeds, as decoated seeds of *Gambeya albida* were the earliest to germinate but had the lowest germination percentage and survival of seedlings because the removal of the seed coat was detrimental to the *Gambeya albida* seeds. Treatment (PC) also germinated quickly following the treatment CR, as the hard seed coat that imposed dormancy had been partially cracked. [26] found that physical scarification was more effective in breaking dormancy of *Rhynchosia minima L.* seeds than chemical scarification with hydrochloric acid. [27] observed that dormancy in *Dalea foliose* seed is due to water impermeable seed coat and can be broken completely by mechanical scarification. However, [28] found that mechanical scarification increased germination of *Glycyrrhiza glabra* seeds to 94-98%. Also [29] opined that manual removal of the inhibiting seed coat in *Picralima nitida* gave the highest germination percentage and rate of germination.

The poorest germination response was observed in treatment with $H_2SO_4$. There was no germination in treatment with 5 mins soaking in 80% $H_2SO_4$ (8H). In this study, a close physical examination of *Canarium schweinfurthii* seed revealed that it had a hole at the posterior continuing down to the embryo. It is therefore possible that, the poor germination could have been the result of the penetration of $H_2SO_4$ through the hole (mycropyle) which probably killed the embryo in treatment with 5 mins soaking in 80% $H_2SO_4$ (8H) as a result of the corrosiveness of the acid. Also the 5 mins exposure might have been too long and harsh for the seed as noted by Muhammad and Amusa [30] that treatment time exerted a significant effect on seed germination of *Tamarindus indica* seeds.

Treatment with 5 mins soaking in 70% $H_2SO_4$ (7H) had 12% mean germination percentage irrespective of the seed source, and this germination could be as a result of difference in $H_2SO_4$ concentration. This suggest that high concentration of $H_2SO_4$ is detrimental to *Canarium schweinfurthii* seeds and as such could damage the embryo. This finding supports [30] who noted that *Picralima nitida* exhibited seed coat dormancy, and that the seed coat could not withstand a long duration of treatment, since treatment with concentrated acid gave lower percentage germination with increased duration of treatment. [31] reported that sulphuric acid pre-sowing treatment gave very low germination result in *Sesbania sesban* because the use of $H_2SO_4$ was not appropriate for seeds that easily became permeable, since the acid penetrates and damages the embryo. However this result was contrary to the findings of Olayode and Gbadamosi [32] who stated that soaking of seeds of *Dialium guineense* in conc. $H_2SO_4$ for long periods was more effective in hastening germination in the species. The observed poor result in this study also contradicts the findings of Muhammad and Amusa [30,33,34] who reported that $H_2SO_4$ is very good for breaking dormancy and improving germination in seeds, especially those with hard seed coats. The duration of exposure of the seeds to the concentrated sulphuric acid is critical since long soaking periods can result in excessive burning of the seed coat, thereby causing damage to the embryo as observed in studies conducted elsewhere [34,35,36].

The germination energy which is the measure of the speed of germination was significantly different and recorded low value in both sources and treatments. This low values implies that *Canarium schweinfurthii* seeds are slow in germination irrespective of seed sources and seed pre- treatments.

This concurs with the findings of Asiedu, et al. [37] who recorded low germination energy values in germination of *Bauhinia rufescens* seeds that were slow in germination. Also the germination value which is the objective means of evaluating the germination test was low and significant irrespective of the seed sources and pre-treatments. This indicates that *Canarium schweinfurthii* seeds have low germination and will take longer time to complete germination as noted by Asiedu, et al. [37] who stated that low germination value is an indication of low germination and longer germination period.

## 5. CONCLUSION

This study revealed that *Canarium schweinfurthii* seeds had seed coat dormancy. The best treatment for enhanced germination percentage was light burning of seeds under dry grass, followed by soaking in water. This investigation revealed that any pre-sowing treatment that will drastically altered the seed coat mechanically or chemically is detrimental to the germination of *Canarium schweinfurthii* seeds as observed in treatments CR, PC, 7H and 8H. Therefore seed coat (testa) plays a very crucial protective role during the germination of this crop. The seeds of *Canarium schweinfurthii* to be used for sowing purposes could be sourced from any location, as there was no significant difference in the germination response between the seeds sources ($T_1$ and $T_2$) used in this study. Sulphuric acid treatment is detrimental to the germination of *Canarium schweinfurthii* seeds and so should not be used.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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