Improvement on Teak (*Tectona Grandis* Linn F.) Germination for Large Scale Afforestation in Nigeria

Omokhua, Godwin E and Alex, A.

Department of Forestry and Wildlife Management, University of Port Harcourt, Port Harcourt, Nigeria
profomokhua@yahoo.com

Abstract: The experiment assessed the effects of 5 main treatments and their respective 4 sub treatments each. The treatments were: Biological scarification plus soaking in water for 0, 6, 12 and 24 hours; cold water for 0 5, 15 and 20 mines; hot water 100^{o}C for 5,10,15 and 20 mines; textraoxosulphate (vi) Acid for 5, 10, 15 and 20 mins; and alternate wetting and drying for 1,2, 3 and 4 days. Germination percentage varied among pretreatment in response to seed storage duration. Biological scarification plus soaking of seed for 24h at 6 months of seed storage gave the highest germination percent of 98.61%. The overall mean germination percentage for the treatments under the 4 storage durations showed significant differences. The highest overall mean germination percent was 78.42% ±7.14 at 6 months of seed storage, while the lowest was 51.80% ± 5.28 for seeds stored for 12 months;Biological scarification has significant implication as the best method to be used in improving seed germination of teak because it is simple, economical and environmentally friendly.

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1. Introduction

Teak (*Tectona grandis* Linn. F.) belongs to the family *Verbenaceae* (Keay, 1989; Wood, 1992). Teak is typically a tree of the moist deciduous forest. It is also found to some extent in evergreen forest. Under optimum condition, this large deciduous tree can attain a height of 30m and a girth at breast-height of over 2m. The species is highly prized and cultivated as plantation tree in tropical and subtropical regions of the world. Teak is considered as one of the finest and most economically valuable timbers species in the tropics, exhibiting desirable technical and decorative properties. The species has both physical and aesthetic qualities. (Folana *et al*., 2008).

The wood of teak is used for numerous purposes such as construction, furniture, poles, veneer, ship building, railway sleepers vehicles building, musical instruments, farm tools, brushes and general carpentry. The young leaves are used as dye and bioabsorbent (Kannan *et al.,* 2008; Rathnakumar *et al.,* 2009).

In Nigeria, recorded history of teak plantations started as far back as the nineteenth century when hundreds of hectares were planted in a number of smaller plantations in Ikom, Idah, Ilorin, Zaria, Oke-Iho, Odo-Ogan, Ogbomosho, Oria, Osun, Akilla, Sapoba and Gambari. Presently, these plantations have been devastated with no reforestation or adequate post harvest management programmes, to ensure a sustainable production of the resources. Therefore, there is a great need for intensifying large scale afforestation using teak in Nigeria.

Teak is one of the most widely and intensively studied tropical timber species, and there are several literatures on its silviculture. As the tree is grown under such widely-varying conditions and circumstances, however, there is no universal agreement on its nursery seed treatments. Hence, the germination of teak seed for large scale afforestation has been a problem in many parts of the world including Nigeria. This creates the need for the development of more or less drastic pre-treatments for the species by improving on it's silviculture to obtain excellent germination. The seed coat of teak is very hard which impose dormancy thus affecting germination (Perez Garcia, 1997). Germination of seed with hard seed coat such as teak could be enhanced by pretreatments. The delay and irregular germination pattern is a serious constraint to efficient nursery management and successful plantation establishment.

One of the major challenges to large scale afforestation is the availability of high quality planting stock of priority trees. The use of seeds as propagules is the easiest and cheapest means of raising seedlings for specific projects. But the problem of many tropical and subtropical tree species is their recalcitrant nature (Hartmann 2002; Berjak and Pammeter, 2004; Vazquez-yanes and Orozcoseqovia, 1993). Furthermore, tropical forest seed germination is a complex process due to known and unknown knowledge of the species. Consequently, germination of the seeds could be influenced by storage duration in diverse ways (Macdonald 2004). Therefore, the objective of this study is to determine the germination response of teak under different storage durations using different pre-germination treatments in the nursery.

2. Research Methods

The study was conducted at the nursery unit of the Department of Forestry and Wildlife Management, University of Port Harcourt. The area is located on latitude 0 40^0 53^I 38.3^{II} N and longitude 006^0 54^I 38.0^{II} E. The climate of the area is tropical with high rainfall of over 2000mm per annum, which is bimodally distributed with peak months as July and September. Mean relative humidity is over 80% per annum, temperatures are usually high, with mean minimum and maximum temperatures as 23^0 and 30^0C respectively. The vegetation of the area is fresh water swamp forest.

Teak fruits were collected at the arboretum of the Moist Forest Research Station of the Forestry Research Institute of Nigeria, Benin City, Nigeria in 2010, fruiting season. The fruits were collected from 10 plus trees. They were collected from randomly selected fruiting branches when they turned from green to brown in colour. The collected fruits were processed by removing the outer coverings.

The seeds were thoroughly mixed and stored in airtight containers for 3, 6 and 12 months respectively in a cold room, plus the control. Seeds for the control experiment were not treated.

A completely randomized design (CRD) was used in this study; seeds for the three storage durations plus the control were sown and monitored at different times after pre-sowing treatments. There were 5 main treatments and 20 sub-treatments, with each main treatment having 4 levels of exposure to a particular treatment procedure. The main treatments were: soaking in cold water, immersion in hot water, alternate wetting and drying, scarification with tetra-oxosulphate (VI) acid and biological scarification using termites.

A total of three hundred seeds were used per sub-treatment involving 3 replicates, during each storage duration experiment. Cold water treatment effect on teak seeds was tested by soaking them in cold water for 1 day, 3, 6 and 9 days respectively. Hot water treatments were done by immersion of teak seeds in hot water (100^0C) for 5, 10, 15 and 20 minutes respectively. Tetraoxosulphate (VI) acid (H_2S0_4:95%) treatment involved immersion of teak seeds for different periods. The immersion periods were for 5, 10, 15 and 20 minutes respectively. The seeds were then washed thoroughly in tap water to remove any trace of the acid.

Alternate wetting and drying involved soaking the seeds in cold water for 1 day and drying them in the sun for another day, this process was repeated for the rest 3 treatment levels but instead of 1 day, the seeds were exposed to alternate wetting and drying for 2,3 and 4 days respectively.

Biological scarification was conducted by use of termites in a mound. An active termite mound was selected for this procedure at the arboretum of the University of Port Harcourt, 120 seeds were buried at a depth of 5cm and covered lightly with 1 cm thick layer of topsoil for 2 weeks. This enabled the termite to scarify the seeds properly. The seeds were removed for pre germination sub-treatments. Sub-treatments in this pretreatment method included; scarification and no soaking in water, scarification and soaking in water for 6h, scarification and soaking in water for 12h and scarification plus soaking in water for 24h.

Germination trays of 60 x 30cm were laid at the nursery and filled with washed and sterilized sharp river sand. Three trays were used per sub-treatment as replicates. Treated seeds plus the control for all the sub-treatments were broadcast on the surface of the trays and covered with a thin layer of river sand. The trays were watered thoroughly to ensure adequate moisture for germination. Germination was taken at emergence of the radicle from the seed coat. Data on germination were recorded daily.

Data obtained for teak seed germination percentage were statistically analyzed using the analysis of variance (ANOVA) procedure of computer Microsoft Excel and SPSS to explore possible treatment variation. Data of treatments were analyzed together to test for significant effect of treatments on germination percentage. Differences between treatment means were separated using the least significant difference (LSD) test at 5% level. Coefficient of variation was also calculated together for the 5 treatments under the different storage conditions plus the control.

3. Analysis of Results

The total germination results obtained in this experiment are presented in Table 1. All the sub treatments had greater germination percentages over the control. In the control experiment, teak seeds had the lowest mean germination percentage of 8.35, 10.38, 18.54 and 8.18% for 0,3,6 and 12 months of storage duration respectively. The mean germination percentage for cold water treatments in relation to teak seed storage were 30.51, 34.16, 57.11 and 39.49% for 0.3, 6 and 12 months of storage duration respectively. Seed stored for 6 months was significantly different from the rest at 5% probability. The longer the cold water treatment, the better the mean germination percentage. Similarly, apart the seeds stored for 12 months, the longer the storage, the better the mean germination percentage from zero to six month of storage. The highest mean germination of 57.11% was recorded from seeds stored for 6 months.

Seed germination under the different H_2S0_4 acid treatment gave enhanced germination percentage for storage duration up to 6 months. The highest germination percentage for the acid pre-treatment was 98.28% at 6 months of seed storage for 20 min treatment time, while the lowest germination percentage for acid pre-treatment was 54.28% at zero storage for 5 min treatment time. The mean germination percentages for H_2S0_4 treatment in relation to teak seed storage were 60.50, 83.94, 95.23 and 61.53% for 0, 3, 6 and 12 months of storage duration respectively. The germination percentages were significantly different from each other at 5% level of probability.

Pre-treatment of seeds of teak with 100^0C hot water for 5, 10, 15 and 20 min, gave lower percentage germination when compared to H_2 $S0_4$ and termite scarification respectively. The highest germination percentage of 58.42% was recorded for seeds subjected to 20 min hot water treatment at 6 months of seed storage. While the lowest germination of 40.18% was recorded for teak seeds subjected to 20 min of hot water at 12 months of storage. The mean germination percentage for hot water treatments in relation to teak seed storage were 56.99, 55.73, 56.29 and 45.27% for 0, 3, 6 and 12 months of storage duration respectively.

Seeds of teak subjected to alternate soaking and drying had mean germination percentages of 57.91, 68.55, 86.26 and 51.30%, for 0,3,6 and 12 months of storage duration respectively. The longer the time of soaking the seed, the better the mean germination. Seeds stored for 3 and 6 months gave the highest mean germination of 68.55 and 86.26% respectively, which were significantly different from each other at 5% level of probability.

If compared to the control and other pre-treatments, biological scarification of teak by using termites had the best germination performance. The longer the time of soaking after termite scarification, the better the germination percentages. Like other pre-treatments including the control, seeds stored for 6 and 3 months had impressive mean germination percentage of 86.15 and 97.23% respectively. The mean germination percentages for the biological scarification of teak in relation to seed storage were 73.56, 86.15, 97.23 and 61.67% for 0,3,6 and 12 months of storage duration respectively. There were significant differences between the mean at 5% level of probability.

The overall mean germination percentage of the treatments under the 4 storage durations showed significant differences. The highest overall mean germination percentage was 78.42 % ± 7.14 at 6 months of seed storage, while the lowest overall mean germination percentage was 51.80% ± 5.28 for seeds stored for 12 months. Analysis of variance for the overall mean germination of teak using the 20 sub-treatments showed that there were significant differences among the overall means for the 4 storage duration (Tables 2, 3, 4 and 5) at 5% level of probability.

Table 1: Mean germination of teak for 4 storage durations using 5 pre-treatments at 8 weeks after sowing (WAS)

Treatment	**Seed storage duration (months)**			
	0	**3**	**6**	**12**
Control	8.35	10.28	18.54	8.18
Cold water storage for 1 day	16.81	20.75	58.75	36.24
Cold water storage for 3 days	27.62	27.88	57.56	40.61
Cold water storage for 6 days	38.45	40.24	55.47	41.72
Cold water storage for 9 days	39.17	43.56	56.36	44.23
Mean	30.51	34.16	57.11	39.49
H_2SO_4 soaking for 5 min	54.28	72.33	92.18	60.12
H_2SO_4 soaking for 10 min	65.12	80.52	94.34	62.74
H_2SO_4 soaking for 15 min	62.34	84.78	96.57	61.22
H_2SO_4 soaking for 20 min	60.29	89.34	98.28	59.78
Mean	60.50	82.94	95.23	61.26
Hot water (100^0C) soaking for 5 min	50.73	55.52	54.19	50.35
Hot water (100^0C) soaking for 10 min	54.57	53.34	57.33	48.11
Hot water (100^0C) soaking for 15 min	56.91	56.28	58.00	41.28
Hot water (100^0C) soaking for 20 min	58.24	58.11	59.42	40.18
Mean	56.99	55.73	58.29	45.27
Alternate wetting/drying (1/1 day)	42.18	67.25	83.15	52.33
Alternate wetting/drying (2/2 days)	50.52	64.37	86.36	53.28
Alternate wetting/drying (3/3 days)	55.31	69.42	85.25	51.17

Alternate wetting/drying (4/4 days)	69.63	72.73	89.17	49.32
Mean	57.91	65.55	86.26	51.30
Termite Scarification, no soaking	70.25	84.12	95.84	62.15
Termite Scarification, soaking for 6 h	72.81	85.38	98.72	60.00
Termite Scarification, soaking for 12 h	75.86	87.24	96.34	63.27
Termite Scarification, soaking for 24 h	76.92	88.17	98.61	63.34
Mean	73.56	86.15	97.23	61.67
Overall mean	6.65 ± 55.90c	5.60 ± 65.49b	7.14 ± 78.42a	5.28 ± 51.80c
LSD (0.05)	5.31	5.45	5.26	5.02
CV (%)	14	16	15	18
Treatment	**0**	**3**	**6**	**12**
	Seed storage duration (months)			

Table 2: Analysis of variance table for mean germination of using 20 treatments at zero teak seed storage duration.

Source of variation	Degree of freedom	Sum of squares	Mean square	F value
Sub-treatments	20	19862	933.10	3.32.
Error	66	19753	299.29	
Total	86	39615		

Significant at 5% level of probability

Table 3: Analysis of variance table for mean germination of using 20 treatments at 3 months seed storage duration.

Source of variation	Degree of freedom	Sum of squares	Mean square	
Sub-treatments	20	22463		
Error 66	66	20285	1,123.15	3.65
Total	86	42748		

Significant at 5% level of probability

Table 4: Analysis of variance table for mean germination of teak using 20 sub-treatments at 6 months of seed storage duration

Source of variation	Degree of freedom	Sum of squares	Mean square	F value
Sub-treatments	20	23734	1186.70	3.57
Error 66	66	21948	332.55	
Total	86	45682		

Significant at 5% level of probability

Table 5: Analysis of variance table for mean germination of teak using 20 sub-treatments at 12 months of seed storage

Source of variation	Degree of freedom	Sum of squares	Mean square	F value
Sub-treatments	20	21328	1066.40	3.58
Error 66	66	19675	298.11	
Total	86	31003		

Significant at 5% level of probability

4. Discussion

The preceding results of this study showed that teak seeds germination was significantly improved by use of pretreatments. Observations recorded among the 5 treatments making up the 20 sub-treatments showed that biological scarification has the best pretreatment for maximum germination of the species for large scale afforestation (Table 1). The use of termite as a biological scarification technique had the highest germination of 98.61% recorded at 6 months of storage. The study has shown that teak seed viability vary under storage duration dependent of length of storage. There was lose in seed viability at 12 months of seed storage. This result is in line with earlier observations by Akinifesi *et al.* (2007). The authors reported low viability of seeds under storage in any wild fruit tree species. Thus seed viability for best of germination teak is restricted to a maximum of 6 months after harvesting and processing.

The use of tetraoxosulphate (VI) acid treatment on teak seeds reflects the way dormancy could be overcome through softening of the testa for germination to occur. Acid treatment of teak seeds gave an impressive mean germination percentage which was next in satisfactory performance to the biological scarification, with 98.28& recorded at 6 months of storage duration (Table 1). The acid treatment in this study could be described as an effective pretreatment technique to maximize teak seed germination. However, the time of exposure of the seeds was significant, the longer the exposure (20 min). The better the mean germination percentage. Care must be taken not to extend time of exposure beyond 20 min, since previous studies have reported seed damage at exposures of 60 min and above which resulted in low germination (Akinifesi *et al.* 2007). Several authors have reported that the use of H_2SO_4 in the treatment of tropical seeds improved seed germination under various conditions (Mabundza *et al.* 2010; Oboho and Urughu 2010; Amusa, 2011; Soloman and Abbas, 2013; Hossain *et al.* 2005; Pinipis *et al.* 2011;).

Another effective pretreatment technique of teak seeds as revealed in this study is alternate wetting and drying. This method is largely used in Asia. In this study, this pretreatment is ranked third after biological scarification using termite and H_2SO_4 pretreatment.

The effect of hot water treatment on teak seed showed that germination was increased as exposure time increased, with the highest germination of 59.42% at 6 months of seed storage and decreased significantly to 40.18% in seeds stored for 12 months at 20 min of hot water exposure. This variable germination behaviour of teak seeds with the different exposure time to hot water implies that the species respond differently to various pretreatments and storage durations dependent on the type of dormancy it possess. The soaking of teak seeds in hot water can rupture the testa, thus allowing water to permeate the inner structures of the seed leading to stimulation of the all important physiological processes resulting in germination. Schmidt (2000) reported that hot water treatment is effective in overcoming physical dormancy in tree seeds.

Teak seeds have a tough seed testa which impedes water imbibitions. Good response of teak seeds to pretreatment techniques is an advantage to large scale afforestation, from this investigation, overall high germination was obtained for biological scarification using termite and H_2SO_4 pretreatment of teak seeds. The better performance of pretreatments over the control suggests the presence of germination inhibitors. Earlier works on germination of tree seeds reported that inhibition was associated with the pericarp and chemical substances, and concluded that these inhibiting substances greatly influenced the ability of tree seeds to germinate (Khan *et al.* 2001; Hartmann, 2002).

5. Conclusion

Conclusively, the result of this study has shown that teak need pre sowing treatment and at least 6 months of seed storage for maximum germination. Therefore, we are led to recommend biological scarification of seeds using termites to foresters and private investors involved in large scale afforestation projects. The recommended method is simple, cheap and less hazardous when compared to tetraoxosulphate (VI) acid which also gave good germination result but very expensive, hazardous and not friendly to the environment.

Corresponding Author:
Dr. Godwin E. Omokhua,
Department of Forestry and Wildlife Management,
University of Port Harcourt, Port Harcourt, Nigeria.
E-mail: profomokhua@yahoo.com

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