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Effects of varying hot water temperatures on the germination and early growth of *Dialuim guineense* (Willd) seeds

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ABSTRACT

Rural dwellers require simple and affordable methods of breaking dormancy of seeds for planting. This study has investigated the effect of varying hot water temperatures on the germination and early growth of Dialium guineense seeds. The treatments were control (untreated), 20^0C, 40^0C, 60^0C, 80^0C and 100^0C. Treated seeds were raised in polythene pots arranged in a Completely Randomized Design manner, with four replications per treatment. Increasing temperature enhanced germination percentage, extended mean time of germination and reduced time of emergence. The 80^0C treatment gave the best germination percentage of 36.88, followed by 100^0C (35.65), 60^0C (33.75), control (28.13), 20^0C (27.50) and 40^0C (25.63). Seedling height ranged between 13.13 – 17.00cm, collar diameter being 0.91cm – 1.12cm and leaf number between 7 – 8 leaves for the temperatures examined. Only height growth was statistically significant. Temperature of 60^0C and above is needed to positively improve the germination and early growth of Dialium guineense seed and 80^0C has been recommended as best treatment. More studies are needed for enhanced early growth rate of this species.

Key words: Seed, dormancy, Dialium guineense, germination, temperature.

INTRODUCTION

Food and Agriculture organization of the United Nation (FAO, 2007) estimated worldwide deforestation at 13 million hectares or 0.7% of the forested area annually. This is caused by increase in land clearing for commercial and subsistence agriculture, logging, commercial fuelwood exploitation, forest fires, expansion of human settlements and industrialization. While problems of deforestation exist globally, the problems can be felt more locally by millions of rural people in tropical countries that depend on trees for subsistence Ochsner et al (2001). Hence, attention is now on how forests can be replenished through various programmes like afforestation, reforestation and agro-forestry, particularly using indigenous species. For tree planting programmes to succeed, it is important to secure viable, genetically superior seeds in adequate quantity. Large plantation schemes of many popular indigenous forest tree species have not been easy to establish for reasons like inherent slow growth, problems of irregular fruiting, pests and diseases as well as seed dormancy. In Nigeria, many indigenous species of ecological, sociological and economic importance have some of these problems. Dialium guineense is one such species. It has slow growth rate and seed dormancy.

Dormancy can be broken either naturally or artificially. Artificially, seed dormancy is broken through the simulation and application of natural dormancy breaking mechanism through the process of pre-treatments. Different pre-sowing treatments have been used to break seed dormancy in many indeginous tropical tree species. They include acid, cold, water, hot water, endocarp removal, and seed coat removal/cracking. Options used by rural dwellers must be well within their reach financially as well as the operational modalities. For acid, there is the risk of handling as well as cost implication. Manual scarification is time consuming and laborious especially with small seeds like those of Dialium guineense. Hot water, often producing modest results for this species, is quite amenable for large quantities of seeds. It is therefore necessary to know the exact hot water temperature requirement that will be favourable in breaking the seed dormancy of Dialium guineense. This is in view of the low cost and convenience/ease of hot water useage by rural planters.

General description of Dialium guineense (Willd)

Dialium guineense commonly known as velvet tamarind, belongs to the family Caesalpinaceae. It is a woody perennial (Plate 1) growing in dense savanna forests, shadowy canyons and gallery forests. According to Keay (1989), it can grow to height of about 20m and 1.2m in diameter with densely leafy crown, but often shrubby and the bole is without buttress. The bark is smooth, grey, slash reddish, yielding a little red gum. The compound leaf has a common stalk 5.13cm long, with a odd terminal leaflet and usually two pairs of opposite or alternate leaflet. The lower pair being some what smaller. It flowers between September – December. The whitish flowers are in large terminal or occasionally axiallary panicles up to 30cm long. The black velvety fruits which occur from February – April are usually abundant, more or less circular and flattened but sometimes globose up to 2.5cm in diameter. Each fruit has a brittle shell enclosing one seed (sometimes two) embedded in a dry brownish, sweetly acidic, edible pulp. There are between 6,000 – 7,000 seeds per kilogramme.

MATERIALS AND METHODS

The study was carried out at the Arboretum of the Department of Forestry and Wildlife Faculty of Agriculture, University of Benin, Benin City, Nigeria. The GPS location indication for the site is Latitude $05^{0}37.429^{1}$E and Longitude $06^{0}24.049^{1}$N. It receives an annual rainfall of over 2000mm in about 160 rainy days and mean temperature of 27^{0}C. The relative humidity is high and uniform, ranging from 75% (afternoon) to 95% (morning) University of Benin Master Plan (1993.)

Fresh fruits (Plate 2) of Dialium guineense were harvested from the Arboretum and depulped to extract the seeds. Percentage purity of 69.23% was obtained after seeds extraction from fruits.

A total of 960 seeds were divided into six seed lots, each lot containing 160 seeds. Each seed lot was subjected to a specific hot water temperature regime as follows:

Control untreated seeds (T_1)
Soaking in hot water at 20^{0}C (T_2)
Soaking in hot water at 40^{0}C (T_3)
Soaking in hot water at 60^{0}C (T_4)

Soaking in hot water at 80^0C (T_5)
Soaking in hot water at 100^0C (T_6)

The seeds were put into beakers, hot water of the specified temperature poured over them and stirring done continuously until cooling. All treated seeds were sown (one each) into small size polythene pot, three – quarter filled with garden soil and weighing approximately 1kg. Routine watering and weeding activities were carried out. The polythene pots were laid out in a Completely Randomized Design manner and there were four replications per treatment. Each replication contained 40 pots.

Germination counts were taken weekly. Seeds were scored as having germinated when the plumule emerged above the soil in the poly-pot. Records of germination spanned a period of 12weeks. Parameters examined included: Germination percentage (GP) calculated as follows:

$$GP = \frac{\text{Total seed germinated}}{\text{Total number of seed sown}} \times \frac{100}{1}$$

- Mean time of germination (MTG) using the equation (Duan et al, 2004, Nadjafi et al, 2006.)

$$MTG = \frac{\sum ni \times di}{N}$$

Where ni = Number of germinated seeds at di days.
di = Incubation period in days at ni
N = Total number of seeds germinated in the treatment.

- CDP = Complete dormancy period = Number of days from sowing to the start of germination.
- PPG = Peak period of germination = period of maximum number of seed germination.
- PGP = Peak germination percentage = total number of seeds germinated at the peak period : by the total number of seed germinated by treatment.

Early growth studies started 10weeks after sowing and germination had begun in all treatments. Ten (10) randomly selected seedlings were tagged per treatment and used for growth investigation. A total of 60 seedlings were used all together. Growth, parameters studied were plant height(cm), collar diameter (cm), and the number of leaves. These parameters were measured forthnightly.

All data collected were subjected to Statistical Analysis of Variance procedure (ANOVA) outlined by Steel and Torres (1984.) Treatment means were separated by the use of Least Significant Difference (LSD) at 0.05 probability level.

RESULTS

The various hot water treatments differently affected the germination of Dialium guineense seeds. Upon emergence, germination was continuous but to varying degrees.

Scanty germination started within the first week of sowing seeds for T_2 (20^0C), T_3(40^0C), T_4(60^0C) and T_6(100^0C.) But for T_1(Control) and T_5(80^0C) germination started in the second week. Both attained emergence and peak germination in the same week of emergence, thereafter followed gradual decline in the germination. Weekly germination counts were more for T_5 (Table 1). Germination progressed from the second week up to the 9^{th} week for T_1 and 12^{th} week for T_5.

Peak germination was attained in the second week for T_2 and T_3. Therefore followed scanty weekly germination up to the 6^{th} week for T_2 and 10^{th} week for T_3. T_4 attained peak germination in the third week after which there followed gradual declined in weekly germination to the 12^{th} week. Peak germination was attained in the fifth week for T_6 (100^0C) and there followed gradual decline in weekly germination until the 12^{th} week, (Fig 1.) There was no statistical differences in the peak period of germination.

T_5 (80^0C) had the highest germination percentage of 36.88. This was followed by T_6 (100^0C) having 35.63; T_4 (60^0C) had 33.75 T_1 (control) and T_2 (20^0C) had 28.13 and 27.50 respectively while T_3 (40^0C) had 25.63. Percentage germination values were however not statistically different with treatment (Table 2)

Complete dormancy period (CDP) or emergence was longest for T_1 (control) being 11days and was significantly reduced to 4 days for T_6 (100^0C) while values for other temperatures ranged between the two extremes. These were not statistically different (Table 2). This indicates that increase in water temperature reduced the period/days to emergence.

Mean time of germination (MTG) that is time over which germination took place varied with treatments. T_1 (control) had the least MTG value of 20days, increasing to 43 days for T_6 (100^0C). These values were statistically significant. Values for treatments T_2 and T_3 were not statistically different from T_1 (control). But values for T_4 (60^0C) and T_5 (80^0C) and T_6 (100^0C) were all statistically different from the T_1 (Control) (Table 2.) There was progressive increase in the average time over which germination took place as temperature increased from 20^0C to 100^0C.

Peak germination percentage values of 37.78, 38.63, 31.71, 18.52, 16.95 and 26.32 were different for T_1 (control), T_2 , T_3 , T_4 , T_5 and T_6 respectively. There were statistical differences between T_1 (control) and all values from T_4 (60^0C) upwards, but values between T_1 (control) up to T_3 (40^0C) were not statistically different (Table 2.)

Growth:

There were obvious height differences between seedlings of varying treatments. At the termination of investigation, T_1 (control) was 13.10cm, T_2 was 14.84 followed by 14.00 (T_3), 14.85 (T_4), 17.00 (T_5) and 15.31 (T_6). Generally, early growth rate was slow, weekly height increase ranging between 0.59 – 0.77cm.

Seedling collar diameter growth was small for all treatments. At 22 weeks collar diameter values were 0.91cm (control, T_1), 0.99cm (T_2) and T_3, 1.03cm (T_4), 1.12cm (T_5) and 1.11cm (T_6).

Leaf number did not vary much between treatments. T_1, T_2 and T_3 had 7 leaves each while T_4, T_5 and T_6 had approximately 8 leaves each. Mean values of the growth parameters (Table 3) only indicated, significant differences in the height growth of seedlings, other parameters being only numerically different. Overall, seeds treated at 80^0C (T_5) produced the best height growth, followed by 100^0C (T_6), 60^0C (T_4), 20^0C (T_2), 40^0C (T_3) and least was control (T_1).

DISCUSSION

Various studies have been conducted in respect of the effectiveness of different pre-treatment methods on forest tree species (Nwoboshi (1982), Onyekwelu and Akindele (2002) and Onyekwelu (2004). No single pre-treatment method is effective for all species since the relative dormancy of species vary in type and degree. It is therefore imperative that every tree grower conducts preliminary investigation to determine what best suits the species being handled. Schmidt (2000) was of the view that in most cases, time factor, safety risk, available equipment and relative cost of pre-treatment methods were important factors of consideration relative to the physiological advantage.

This investigation has shown that the various water temperature treatments produced varying effects on the germination and early growth of Dialium guineense seeds. All treatments above 60^0C gave better results than control (T_1) but 80^0C (T_5) gave the best all round effect. It gave the highest (36.88) germination percentage and least peak germination percent. The latter being a result of the more continuous and higher weekly germination values right from time of emergence to the end of germination period. T_6 (100^0C) was second in effectiveness. The moderate effect of the 80^0C probably made the seed coat to become adequately softened to absorb enough water for imbibitions rather than weaken the embryo due to the high temperature at 100^0C. This is further supported by the fact that even though T_6 started germination in the first week, it did not attain peak germination until the 5^{th} week. This study agrees with the recommendation of Bowen and Eusebio (1981) who recommenced water temperature of 80^0C – 90^0C for Albizzia falcataria. Saikou et al (2008) also found that treating Acacia senegal with hot water at 80^0C for 10 – 40 minutes gave the best results.

Temperature increase has proven to extend the mean time of germination, being lowest (20.76 days) for the control (T_1`) seeds and increasing to 43.15 days for T_6(100^0C) and more significanty so above the 60^0C temperature. Trong and Hans (2007) reported that high temperature may affect either initial processe of water uptake by seeds or biochemical processes that result in cell division. T_4 (60^0C) ranked third in this study Egharevba et al (2005) working on Plukenetial conophorum (African walnut) also observed that warm water at 60^0C ranked third in their germination trial. T_2 (20^0C) and T_3 (40^0C) ranked fifth and sixth respectively in germination performance. Although only being numerically different from T_1 (control.) This is an evidence that hot water temperature of at least 60^0C is necessary to positively enhance the germination of Dialium guineense seeds.

Seedling growth performance followed similar pattern as that of germination. Treatments significantly affected plant height but not collar diameter and leaf number. Primary and secondary stem(s) of the young plant increase in length by cell division and internode elongation from the first stem node upward. The second and subsequent leaves develop at each stem node as growth continues. Once the first leaves develop, further growth and development is best described by the number of leaves that develop on the main shoot as the plant continues to grow, Dwain (1999). This therefore indicates the possibility that the internode elongation of seedlings effected even by the best treatment (T_5) was not more than other treatments in terms of the required length that could lead to the production of more leaves. Leaves are vital to photosynthesis and biomass production. Since the hot water temperatures could not significantly change leaf number it therefore follows that collar diameter would similarly not be increased significantly as evidence from this study. Also, growth of young seedlings are initially concentrated on elongation rather than diameter and increase in diameter of plant axes are brought about by the activities of vascular and cork cambia not yet prominent in the early growth phase.

Plate 1: A young tree of *Dialium guineense*

Plate 2: Fruits of *Dialium guineense* tree

TABLE 1: Germination trend of dialium guineense seeds under varying hot water temperature treatments

TREATMENT	SEEDLING GERMINATION COUNT IN WEEKS AFTER SOWING													
	1	2	3	4	5	6	7	8	9	10	11	12	∑x	$\bar{X}$
Control (T_1)	0	17	10	3	4	4	0	4	3	0	0	0	45	3.75
H_20 at 20^0C (T_2)	1	17	10	2	4	1	1	1	2	1	1	3	44	3.67
H_20 at 40^0C (T_3)	2	13	8	3	4	4	2	1	2	3	0	0	41	3.42
H_20 at 60^0C (T_4)	3	8	10	1	9	4	3	4	5	2	3	2	54	4.50
H_20 at 80^0C (T_5)	0	10	7	5	6	5	7	7	4	5	2	1	59	4.92
H_20 at 100^0C (T_6)	1	5	4	5	15	6	4	5	2	4	4	2	57	4.75

Fig 1: Germination trend with varying hot water temperatures on seeds of Dialium guineense.

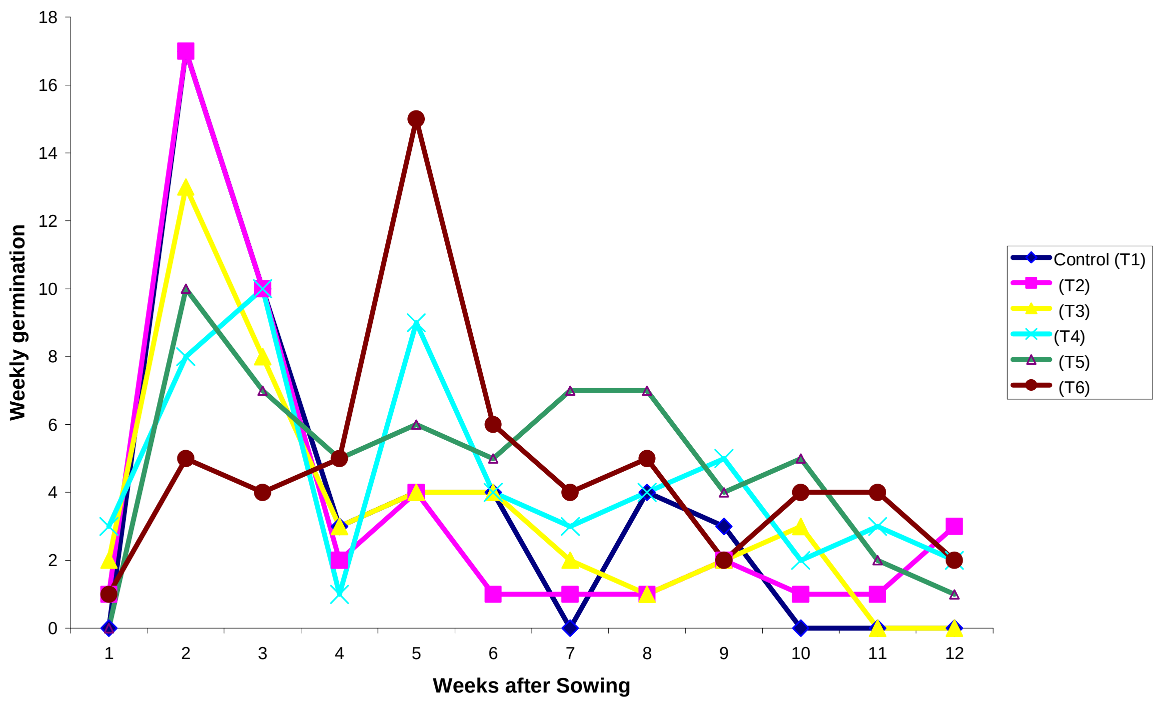

TABLE 2: Effect of varying water temperature treatments on germination parameters of *Dialium guineense*

Treatment	PG (%)	CDP (days)	PPG (weeks)	PGP (%)	MTG(days)
Control (T_1)	28.13	11	2	37.78	20.76
H_20 at 20^0C (T_2)	27.50	7	2	38.63	30.07
H_20 at 40^0C (T_3)	25.63	5	2	31.71	30.00
H_20 at 60^0C (T_4)	33.75	5	3	18.52	38.50
H_20 at 80^0C (T_5)	36.88	8	2	16.95	41.51
H_20 at 100^0C (T_6)	35.63	4	5	26.32	43.15
LSD (P=0.05)	16.14	6.33	5.39	7.42	13.39

Generally the results from the statistical analysis indicated no significant difference between the mean values of the treatments.

TABLE 3: Effect of varying hot water temperatures treatments on the mean growth of Dialium guineense seedlings

	MEAN GROWTH PARAMETERS		
Treatments	Height	Collar girth	Leaf number
Control (T_1)	11.26^a	0.69^c	6.40^d
H_20 at 20^0C (T_2)	13.37^{ab}	0.78^c	6.50^d
H_20 at 40^0C (T_3)	12.38^a	0.76^c	6.34^d
H_20 at 60^0C (T_4)	12.94^{ab}	0.78^c	6.77^d
H_20 at 80^0C (T_5)	14.66^b	0.88^c	6.70^d
H_20 at 100^0C (T_6)	13.19^{ab}	0.83^c	6.83^d

**Means followed by the same letters above columns are not significantly different.*

CONCLUSION

The effects of varying hot water temperatures on germination and early growth of Dialium guineense seed has been investigated. Generally, germination commenced within the first 2 weeks of sowing for all treatments, extending to between 9 – 12 weeks of continuous germination although values varied with treatments. There were discernable effects on time of germination, percentage germination, peak percentage and mean time of germination. Generally, the growth rate of Dialium giuneense was slow, with an average height growth of 0.68cm per week at this juvenile phase. After 22 weeks of growth, the seedlings attained between 13.10 - 17.00 cm height, 0.91 – 1.12 cm collar diameter and leaf number of 7 – 8 for the investigated temperatures. Treatments significantly affected, mean time of germination, peak germination percentage and height growth. Germination percentage was numerically enchanced by temperature increase. Temperature reduced the period to emergence and extended the germination time. T_5 (80^0C) was the best temperature for treating seeds of Dialium guineense and this has been recommended for rural planters. This recommended temperature could be practically obtained in the Benin City environment by boiling water and allowing it to cool for 3 minutes. Plant breeding and fertilizer studies should be carried out to improve the growth rate of this species in the juvenile stage.

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