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Influence of storage temperature and duration interaction on germination performance of *Drypestes gossweileri* (S. MOORE)

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ABSTRACT

This study investigated effects of storage temperature, duration interaction, on germination and seedling growth of *Drypestes gossweileri*. The study was conducted in two phases. In the first phase, three levels of storage temperature (-4oC, 10oC and 27oC) and four levels of storage durations (1, 7, 14 and 21 days) were used. Germination parameters (final germination percentage, time to first germination and mean germination time) and seedling growth parameters (seedling height, collar diameter, leaves number and area) were assessed for storage temperature and duration. Data obtained were subjected to analysis of variance and means were separated using Least Significant Difference at p≤0.05. Results showed that *D. gossweileri* seeds stored for one day had best germination and seedling growth across all storage temperatures. Regardless of storage duration, seeds stored at 10oC exhibited best germination. Therefore, optimum storage temperature for *D. gossweileri* seeds for optimal germination and seedling growth is 10oC, and the seed should not be stored beyond a day for optimum performance.

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INTRODUCTION

Storage temperature on germination and growth of seed is strongly linked to its effects on metabolic activities occurring before and during germination. Wilcox and Pfeiffer (1990) explained that there is a specific temperature that is favourable for metabolic activation of the seed embryo, which trigger the beginning of germination. In addition, activation of enzymes and synthesis of new materials prepare the seed radicle and epicotyl for elongation, thereby transmitting to seedling growth. Sub-optimal or super-optimal seed storage temperature can lead to seed dormancy (Tuan *et al*., 2019). Seed dormancy and ripening are significantly influenced by the temperature of storage (Bojovic, 2010).

Drypestes gossweileri commonly known as horseradish tree belongs to the family Euporbiaceae, it is deciduous tree when matured with a straight cylindrical trunk, rough surfaced and grey colored bark with a pungent smell. The tree growsup to 42 m in height. The bole of the plant is straight up to 120 cm in diameter. When cut, the bark is greyish green to yellowish green, with many lenticels and a pungent odour (Letouzey, 1982; Guyot, 1992).It is a medicinal plant; with almost all parts locally for medicine (Wansi*et al*., 2016). The bark decoction or maceration is use for the treatment of typhoid diarrhea, expel intestinal worms and can also be applied as an enema (Tchinda and Sob, 2008). The bark of the tree is use for the treatment of rheumatism and it has anthelmintic properties (Adjanohoun*et al*., 1988). *D. gossweileri* bark and stem have been reported to be useful in treating toothache, dysentery, gonorrhea, coryza, sinusitis, boils and swellings (Bouquet, 1969; 1974). The root of the tree has been active in the treatment of wounds (Troupin, 1983). The plant has antibacterial, antioxidant and antiradical effects (Agnaniet*et al*., 2003; Ijah and Oyebanji, 2003)

The storage temperature such a tree is an integral factor in the process called after-ripening of the fruits(Kucera*et al*., 2005; Bethke*et al*., 2006). Baskin and Baskin (2004) reported that there is a temperature requirement for seed to break physiological dormancy, embryo growth and ability of gibberellic acid to overcome dormancy in every tree species. Inappropriate storage temperature in tree species can result into seed losing its viability,many seeds especially those of the tropical origin are quite sensitive to temperature and cannot be stored at temperature lower or higher temperature (Tommasi*et al*., 2006). Inadequate information on the silvicultural requirement on the temperature requirement of most forest species including *Drypestes gossweileri*poses big threat to their conservation practices;hence the study investigates the effects of storage temperature duration interaction on seed germination and seedling growth of *Drypestes gossweileri* in the nursery.

MATERIALS AND METHODS

Study area

The study was conducted at the nursery section, in Forestry and Wildlife Management, Faculty of Agriculture, University of Port-Harcourt, Rivers State. The section lies between latitude 04^0 53'38.30'N and longitude 00.6^0 54' 38.0'E (Omokhua, *et al*., 2015).

Seed Collection

Matured seeds of *Drypestes gossweileri* were collected from five (5) mother plus trees in a natural forest reserve in Sakpomba, Edo State Nigeria. The seeds were mixed thoroughly to form seed lot for the study

Seed viability test was done, using flotation method

Flotation method was used for the viability test of the seeds. The seeds of *D. gossweileri* were tested for seed viability before used in the study. The seed lot collected was poured into a big bowl with clean water for 20 seconds. The seeds that sank were regarded as the viable seeds and were used in this study, while the seeds that floated were regarded as nonviable seeds and discarded. The study was conducted according to the International Seed Testing Association (ISTA, 2005). The experiment was initiated twenty-four hours (24) after fruits were harvested.

Experimental design and treatment procedure

A completely randomized factorial design was used to evaluate the effects of storage temperature and duration on germination indices of *D. gossweileri*. Three (3) storage temperatures (-4^{o}C, 10^{o}C and 27^{o}C). Shortly after harvesting the seeds of *D. gossweileri,* they were stored for 0 day, 7 days, 14 days and 21 days at different storage temperature of 27^{o}C (room temperature), 10^{o}C (refrigerator), and -4^{o}C(freezer). The seeds for each treatment were parked and stored in three (3) labeled envelopes of twenty (20) seeds each. a total of twelve (12) experimental units, resulting from the factorial combination of the three (3) storage temperatures and four (4) storage duration. The sowing medium (topsoil) was sterilized in an oven at a temperature of 100^{o}C to control the soil borne pathogens. Similarly, the germination trays were washed thoroughly with distilled water and disinfected to prevent pathogen infections.

The seeds were sown horizontally in germination trays filled with sterilized top soil at a depth of 2cm. The germination trays were watered daily and observed for germination of seeds. Germination was taken to have occurred at the point of plumule emergence. Each treatment was replicated three (3) times with twenty (20) seeds each, given a total of sixty (60) seeds per treatment and a total of seven hundred and twenty (720) seeds were used for the experiment. The seeds were sown horizontally in all treatments using germination trays filled with sterilized top soil. Data were collected on germination speed, mean germination time and germination percentage.In assessing seedling growth parameters, ten (10) seedlings of *D. gossweileri* were randomly selected from each treatment and transplanted into 4kg polythene pots filled with top soil. Each poly pot represented individual replicate. They were watered daily and observed for twenty (20) weeks. The seedlings were measured for survival length, collar diameters, and leaf production at five (5) months of growth.

Statistical Analysis

All the data collected on effects of storage temperature on seed germination and seedling growth of *D. gossweileri* were subjected to analysis of variance (ANOVA) significant means were separated by using Least Significant Difference (LSD) at 0.05 probability level.

RESULTS

Effect of storage temperature and storage duration interaction on germination performance of *D. gossweileri*

The interaction effect of storage temperature and storage duration on germination performance of *D. gossweileri* (Table 1) showed that seeds stored for 21 days at 27^{o}C had the significantly longest time of first day germination (TFG) (28 days), while seeds stored for 0, 7 and 14 days at 27^{o}C had statistically similar TFG (19.33, 21, and 21 days respectively) (Table 1). Seeds stored for 21 days at 10^{o}C had the significantly longest TFG (48 days). Seeds stored for 7 and 14 days at 10^{o}C had statistically similar TFG (35 and 36 days respectively), however, seeds stored for a day at 10 ^{o}C had the shortest TFG (21 days). Similarly, seeds stored 21 days at -4^{o}C had the significantly longest TFG (42 days), seeds stored for 7 and 14 days at -4^{o}C had TFG of 39 and 40 days respectively which was not significantly different from each other, while seeds stored for a day at -4^{o}C storage temperature had the shortest TFG (28 days).

The interaction effect of storage temperature and storage duration on germination performance of *D. gossweileri* revealed that seeds stored for 21 days at 27 ^{o}C had the significantly longest mean germination time (MGT) (48 days), while seeds stored for 1, 7 and 14 days at 27 ^{o}C had similar MGT (35, 35, and 36 days respectively) (Table 1). Seeds stored for 27 days at 10 ^{o}C had the longest MGT (61 days) which was significantly different from seeds stored for 14 days at 10 ^{o}C (48 days), while seeds stored for 1 and 7 days at the same temperature had the same MGT (35 days each). Seeds stored for 21 days at -4^{o}C also had the significantly longest MGT (61 days) while seed stored for a day at the same temperature had the significantly shortest MGT (48 days. Seeds stored for 7 days at -4^{o}C had 56 days MGT which was not significantly different from seed stored for 14 days at the same temperature which had 57 days MGT.

The interaction effect of storage temperature and storage duration on germination performance of *D. gossweileri* revealed that germination percentage (GP) of seeds stored for a day at 27^{o}C was the highest (63.33%), though not significantly different from seeds stored for 7 days at 27^{o}C (51.67%) which was also statistically similar to seeds stored for 14 days at the same temperature (43.33%) (Table 1). Seeds stored for 21 days at 27^{o}C had the least germination percentage (GP) (40%), nevertheless, it was not significantly different from seeds stored for 14 days at the same temperature. The FGP of seeds stored for 1, 7, 14 and 21 days at 10 ^{o}C was not significantly different from one another (85, 86.67, 90 and 88.33 respectively). Seeds stored for a day at -4^{o}C had the highest FGP (61.67%), though not significantly different from seeds stored for 14 days at -4^{o}C (55%) which was also statistically similar to seeds stored for 7 days at the same temperature (43.33%). Seeds stored for 21 days at -4^{o}C had the least FGP (30%), however, it was not significantly different from seeds stored for 7 days at the same temperature.

Table 1. Effect of storage temperature and duration interaction on the germination of *D. gossweileri* seeds

Storage duration

Storage Temperature	1	7	14	21
Time of First Germination (days)				
-4ºC	28.00±0.585[c]	39.00±0.585b	40.00±0.585b	42.00±0.585[a]
10ºC	21.00±0.585[c]	35.00±0.585b	36.00±0.585b	48.00±0.585[a]
27ºC	19.33±0.585[b]	21.00±0.585b	21.00±0.585b	28.00±0.585[a]
Mean Germination Time (days)				
-4ºC	48.00±0.57[d]	56.00±0.57b[c]	57.00±0.57[b]	61.00±0.57[a]
10ºC	35.00±0.57[c]	35.00±0.57[c]	48.00±0.57[b]	61.00±0.57[a]
27ºC	35.00±0.57[b]	35.00±0.57[b]	36.00±0.57[b]	48.00±0.57[a]
Germination Percentage (%)				
-4ºC	61.67±3.57a	43.33±3.57bc	55.00±3.57ab	30.00±3.57c
10ºC	85.00±3.57a	86.67±3.57a	90.00±3.57a	88.33±3.57a
27ºC	63.33±3.57a	51.67±3.57ab	43.33±3.57bc	40.00±3.57c

Means with the same alphabet on a row are not significantly different using LSD at 5% probability except for the grand mean of temperature which are along the column.

Effect of storage temperature and storage duration interaction on seedling growth performance of *D. gossweileri*

The interaction effect of storage temperature and storage duration on seedling growth performance of *D. gossweileri* revealed that seeds stored for a day at 27 ºC had the highest seedlings height (SH) (77.80 cm) and was different from that of seeds stored for 7 days at the same temperature (71.50 cm) (Table 2). Seeds stored for 14 and 21 days at 27ºC had similar SH (58.50). Seeds stored for 1 and 7 days at 10ºC had statistically the same seedlings height (SH) (71.90 and 73.70 cm respectively), likewise, seeds stored for 14 and 21 days at 10 ºC had statistically the same seedlings height (SH) (57.00 and 57.80 cm). The seedlings height (SH) for seeds stored for 1, 7 and 14 days at -4ºC were similar (41.50, 41.00 and 40.80 cm respectively) while seeds stored for 21 days at -4ºC had the significantly shortest seedlings height (SH) (37.30 cm).

The interaction effect of storage temperature and storage duration on seedling growth performance of *D. gossweileri* indicated that seeds stored for 1 and 7 days at 27ºC had similar collar diameter (CD) (4.70 and 4.40 mm respectively), also, seeds stored for 14 and 21 days at 27ºC had the same collar diameter (CD) (3.00 mm) (Table 1). The collar diameter (CD)of seedlings stored for a day at 10ºC was only significantly different (and highest) in seeds stored for a day (4.50 mm), while seeds stored for 7, 14 and 21 days at 10 ºC had the same CD (3.00 mm). Similarly, the CD of seeds stored for a day at -4ºC (3.00 mm) this was significantly different from that of seeds stored for 7, 14 and 21 which had 2.00 mm.

The interaction effect of storage temperature and storage duration on seedling growth performance of *D. gossweileri* indicated that the leaf number (LN) of seeds stored for a day at 27ºC (16) was significantly different from that of seeds stored for 7 days at 27 ºC(14), but, the leaf number (LN) for seeds stored for 14 and 21 days at 27ºC were not significantly different from each other (11 and 10 respectively) (Table 2). The leaf number (LN) for seeds stored for a day at 10ºC was significantly the highest (15) while seeds stored for 7, 14 and 21 days at 10ºC had the same leaf number (LN) (10). The leaf number (LN) for seeds stored for 1 and 7 days at -4ºC were the same (10), the seeds stored for 14 and 21 days at -4ºC had the same leaf number (LN) (6).

Table 4. Effect of storage temperature and duration interaction on the seedling growth of *D. gossweileri* seeds

	Storage duration			
Storage Temperature	1	7	14	21
Seedling Height (cm)				
-4ºC	41.50±1.53a	41.00±1.53a	40.80±1.53a	37.30±1.53b
10ºC	71.90±1.53a	73.70±1.53a	57.00±1.53b	57.80±1.53b
27ºC	77.80±1.53a	71.50±1.53b	58.50±1.53c	58.00±1.53c
Collar Diameter (mm)				
-4ºC	3.00±0.09a	2.00±0.09b	2.00±0.09b	2.00±0.09b
10ºC	4.50±0.09a	3.00±0.09b	3.00±0.09b	3.00±0.09b
27ºC	4.70±0.09a	4.40±0.09a	3.00±0.09b	3.00±0.09b
Leaf Number				
-4ºC	10±0.26a	10±0.26a	6±0.26b	6±0.26b
10ºC	15±0.26a	10±0.26b	10±0.26b	10±0.26b
27ºC	16±0.26a	14±0.26b	11±0.26c	10±0.26c

Means with the same alphabet on a row are not significantly different using LSD at 5% probability except for the grand mean of temperature which are along the column.

DISCUSSION

Effects of storage temperature and storage duration interaction on germination performance of *D. gossweileri*

Seed germination is important to plant development, and it is considered as the determining factor in plant productivity (Ali and Elozeiri, 2017). Though it is difficult to single out the effect of one factor as the determining factor to seed germination (Wilcox and Pfeiffer, 1990), but, studies have shown that storage temperature and storage duration can significantly make-or-break the germination process of seed (Ellis and Roberts 1981; Corbineau *et al*., 1986; Eberle*et al*., 2014).Results revealed that seeds of *D. gossweileri* that were stored for a day had the highest FGP and the shortest TFG and MGT across all the storage temperatures. Also, the higher the storage duration, the lesser was the FGP and the longer were the TFG and MGT across all the storage temperatures. This implied that the seeds of *D. gossweileri* does not have dormancy since freshly harvested seeds readily germinate after been stored for just one day, and the seeds should not be stored beyond a day under any storage temperature condition for effective germination performance. The lower FGP, and higher TFG and MGT for seeds stored for longer duration (7, 14 and 21 days) across all storage temperature indicates delayed germination at longer storage duration. The was similar with the report of (Roberts, 1972; Harrington, 1973; Villiers, 1973) which states that While some seeds could be stored for a long term, some are very sensitive to storage and they required to be sowed almost immediately after the mature seeds have been harvested to prevent physiological aging. Prolong storage periods may lead to bio-chemical changes and natural aging which deteriorates the seed and reduces energy to germinate (Olosunde*et al.*, 2017). Similar result was observed for seeds of *Brassica campestris, Rumexscutatus*, and *Triplochiton scleroxylon*(Verma and Tomer, 2003; Yilmaz and Aksoy 2007; Boadu and Siaw, 2019). Zheng and Ma (2014) researched the seeds of *Bombaxceiba* and reported that germination percentage reduced with increase in the number of incubation days. Nevertheless, there is improvement in seed quality and increase in germination of some plant species with increase in storage duration(Mubvuma*et al.*, 2013).

Temperature is one of the factors that determine the rate at which seeds deteriorate (Walters *et al.*, 2010). All plant species have specific temperature for their optimum seed germination (Nagar, 2016). The seeds of *D. gossweileri* stored at temperature of 10 ºC had better first time germination percentage (FGP) compared to other storage temperatures irrespective of storage duration. This suggested that the optimum storage temperature for the seeds for optimum germination is 10 ºC. Similarly, when *Carica papaya* L. seeds were stored at 15 ºC, they maintained their optimum germination, but lost viability when stored at cooler or hotter temperature (Ellis *et al.*, 1991). Comparatively, seeds of *Swertiachirayita* produced high seed germination, low mean germination time, and low rate of fall in seed germination percentage when stored at 4 ºC, but at lower temperature, the germination performance reduced (Pradhan and Badola, 2012). On the basis of the response to germination when stored at subzero temperature, the seeds of *D. gossweileri* can be classified as recalcitrant. Recalcitrant seeds lose their viability when stored at subzero temperature (Zheng *et al.*, 2016). The poor germination of *D. gossweileri* seeds at subzero temperature (-4 ºC) could be due to the fact that the tree species is a predominant tropical plant. *D.*

gossweileri is domestic to tropical forest of west and central Africa countries (Dupont, 1997; Tchinda and Sob, 2008). Kim and Han (2018) studied 17 tree species and established that most tropical plant species germinates optimally between 10-45 ^{o}C temperatures. Though the seeds of *D. gossweileri* stored at 27 °C had the shortest TFG and MGT, however, the reduced FGP of seeds of *D. gossweileri* stored at 27 ^{o}C means that the rate of germination may be great at high temperature but the germination vigour is hindered. This compared well with the seeds of *Pinusdensiflora, Pinusthunbergii* and *Maackiaamurensis*(Kim and Han, 2018).

Effects of storage temperature and storage duration interaction on seedling growth performance of *D. gossweileri*

The growth of plant seedling is a function of seed storage duration and storage temperature (Soltani et al., 2009; Sarić-Krsmanović*et al*., 2015). The storage condition of the seed being sowed is a determining factor in plant development and plant productivity (Ali and Elozeiri, 2017). Every plant species has specific temperature range for seed germination and establishment of seedling (Bradbeer, 1988). Seeds of *D. gossweileri* stored for a day had the best seedling growth performance across all the storage temperatures as measured by SH, CD and NL. This is likely due to better germination performance of the seeds stored under the same storage condition. The result of this study suggested that storing the seed of *D. gossweileri* for just a day before planting gives better seedling growth under any temperature condition, while seedling growth reduced with increase storage duration. Reports suggested that increasing storage duration reduces seedling performance of several plant species(Dell' Aquila and Di Turi, 1996; Joaoabba and Lovato, 1999; Verma*et al.*, 2003). This also agrees with the report of Zhang et al. (2005) that the seedling growth reduced with increase in storage duration. On the contrary, the seedling had higher seedling growth performance with increase storage duration (Silveira*et al*., 2014).

The seedling performance of *D. gossweileri* was greatest when the seeds were stored at 27 ^{o}C, however, seeds stored at -4 ^{o}C had the least seedling growth performance irrespective of the storage duration. This showed that storing the seed of *D. gossweileri* at low temperature (≤ -4 ^{o}C) might be detrimental to its seedling growth. This further shows that viability and growth performance of tropical species would reduce drastically when their seeds are stored at low temperature and storing them at a temperature between 10-45 ^{o}C will enhance both germination and seedling growth performances (Kim and Han, 2018). The temperature cycle of an area plays significant role in germination of seed and seedling establishment (Baskin and Baskin, 1988).

CONCLUSIONS AND RECOMMENDATIONS

This study concluded that that storing the seed of *D. gossweileri* for just a day before planting gave better germination and seedling growth performance under any temperature condition, while seedling growth reduced with increase storage duration. The optimum storage temperature for the seeds of *D. gossweileri* optimum germination and seedling growth is between 10 and 27 ^{o}C. This study therefore recommended that the seeds of *D. gossweileri* should be stored between 10 and 27 ^{o}C for optimum germination and seedling development, and should not be stored at subzero temperature. The seeds of *D. gossweileri* should not be stored beyond a day as its germination and seedling performances reduced with increase in storage duration.

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