GERMINATION AND EARLY GROWTH OF *Terminalia ivorensis* A. Chev. AND *Khaya senegalensis* (Desr.) A. Juss.

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ABSTRACT

Nursery experiments were conducted during the rainy season to assess the early growth of Terminalia ivorensis and Khaya senegalensis seedlings in order to ascertain the suitability of the species for possible plantation establishment in Nigerian drylands. One hundred seeds from each species were germinated, and ten uniformly growing seedlings were selected from each species at two weeks-after-planting. Growth assessment was carried out for 4 months, after transplanting These were sown in 25 cm x 25 cm polypots filled with topsoil and replicated 4 times. Germination Percentage (GP) of seeds was determined; and Mean Germination Time (MGT) was ascertained using germination kinetic models. Terminalia ivorensis had a mean height/month of 12.31 cm, while Khaya senegalensis was 13.97 cm. Mean number of leaves/month were 10.88 and 9.20, while mean basal diameters were 1.98 mm and 11.20 mm, for Terminalia and Khaya seedlings , respectively. Mean biomass raw-weights were 1.29 g and 1.43 g, while mean dry biomass were 0.76 g and 0.84g for the concurrent species. There were no significant differences in the height and number of leaves of the two species, while their basal diameters differed. The nursery performance of both species indicate their ameliorability to growth in drylands. Hence, Terminalia ivorensis and Khaya senegalensis could be raised for large scale afforestation or reforestation in the dryland environments.

Keywords: Timber species, Seed germination, Early growth, Indigenous hardwoods

INTRODUCTION

Terminalia ivorensis A. Chev and *Khaya senegalensis* (Desr.) A. Juss. are timber tree species found in different ecological zones of Nigeria (Keay, 1989). The former is mostly found in the rainforest zone, as it requires high, well-distributed rainfall for growth and development, while the latter is more common in the drylands, within the higher rainfall savanna woodlands, or along rivers and streams that extend into the savanna in the drier portions of its range (ICRAF, 2016). Seed dormancy has been identified as a major hinderance to the propagation of many tropical hardwood species (Gbadebo and Salami, 2008). This dormancy could either be naturally inclined or inertly imposed during the storage process (Salami, 2018). This difficulty in the regeneration process may further pose a serious silvicultural challenge, especially with the rate at which indigenous multipurpose tree species are fast declining (Borokini *et al.,* 2013; Onefeli and Akinyele, 2014; Onefeli and Agwu, 2015).

Terminalia ivorensis is a large deciduous forest tree, in the family Combretaceae. This large forest tree produces the well-known timber called Idigbo. It is also commonly known as Black Afara. The plant species is similar to *Terminalia superba* in habit but can be readily distinguished by the dark, often

blackish, and deeply fissured bark (Keay, 1989). It ranges in height from 15 m to 46 m, extending to 50 m and above, and can be branchless for up to 30 m of its total height. The diameter at breast height ranges from about 2 m to 4.75 m (Orwa *et al.,* 2009). Leaves of *T. ivorensis* are 6.4 cm - 12.7 cm long by 2.5 cm - 6 cm broad, usually narrowly obovate, abruptly and shortly acuminate. The leaves are whorled, simple, oval, blunt-tipped with orange-brown hairs below and veins above on short stalks (ICRAF, 2016).

Black Afara is native to West Africa and is propagated through seeds, with about 5500 - 7300 seeds/kg (Orwa *et al.,* 2009). The plant has orthodox seed storage behaviour, and seeds had maintained viability at 8.6% moisture content (M.C.) and storage at room temperature for up to 3 or 4 months. They can also be stored as dry fruits. Flowering is between April and August, while fruiting commences from July, persisting till the following dry season. The tree begins fruiting from age 15 and 25 and up to 37 years (Orwa *et al.,* 2009). The fruits are produced annually in large quantities from December, becoming abundant from January to March, and then ripening in 6 - 9 months after flowering. The species is wind dispersed and bunches of brown fruits become conspicuous when the tree is leafless in the dry season (Haysom and Murphy, 2003). *Terminalia ivorensis* is a useful timber species with yellow-brown wood, similar to oak. It dries quickly and is used for most durable construction works. It is similar in weight to mahogany, having a wood density of 450 - 675 kg/m³ at 12% M.C. (Smith *et al.,* 2004). The species provides economic, medicinal, spiritual, and social benefits. The tree provides good shade and is planted with coffee, banana, and cocoa in agroforestry practices (Alamu and Alabi, 2015).

Khaya senegalensis is commonly called the Dry Zone Mahogany and from the family Meliaceae. It is a deciduous evergreen tree, 15 m – 30 m high, and expands to between 1 m – 3 m in diameter, having a clean bole to between 8 m – 16 m of its total height (Keay, 1989). The species does not have prominent buttresses, while the leaves are alternate and compound. They are between 13 cm – 33 cm long with 3 to 7 leaflets that are usually opposite pairs. The leaflets are oblong to narrowly oblong-elliptic in shape and 4 – 12 cm by 2 – 5 cm in size (ICRAF, 2016).

The Dry Zone Mahogany is native to Africa and is widely distributed in the savanna regions, particularly in riverine forests with higher rainfall (Keay, 1989). It is planted ornamentally as a roadside tree, or as a timber species. The tree fruits from December to April, producing brown seeds, six or more per cell. The fruit pods are transversely ellipsoid to flat, with narrowly winged margins. Fruting commences from 20 - 25 years old, and there are about 6000 - 7000 seeds/kg (Orwa *et al.,* 2009).

The timber wood of *K. senegalensis* is a typical reddish-brown mahogany, heavy and in high demand in the savanna regions. It is one of the hardest African mahoganies, and the hardest of the *Khaya species*. The wood density ranges from 0.60 to 0.85 kg/m^3 (Keay, 1989). The sapwood is pinkish-tan in colour, and the heartwood is an attractive dark red-brown. It is moderately resistant to fungi, insects, and termites. The presence of oleoresin in the vessels of this species

increases its durability and resistance to insect and fungal attacks (ICRAF, 2016). It is highly favoured for furniture, and high-class joinery, as well as for trim and boat building. The wood is also used locally for railroad ties, flooring, turnery, and veneer. The wood fibre is used in West Africa for pulp, while the bark is used in the tanning industry. The young leaves contain large amounts of digestible crude protein and are used as fodder for cattle and camels (Dorthe and Sylvie, 2003). The seeds have an oil content of 67% and are rich in oleic acid (66%), which is used for cooking in West Africa. The wood ashes are also used for storing millet seeds (Orwa *et al.,* 2009). Nonetheless, the low level of natural regeneration of some indigenous tree species (Onefeli *et al.,* 2014; Jegede *et al.,* 2020) is a great cause for concern. Wildlings of such tree species are not readily found under their mother trees, especially in the savanna regions (Gbadebo and Salami, 2008).

As Nigeria is facing a scarcity in wood supply, with the depletion of timber resources in natural forest. Timber species such as *T. ivorensis* and *K. senegalensis* have experienced over-exploitation with little or no natural and artificial regeneration (Salami, 2018). In view of these, the International Union for Conservation of Nature (IUCN) Red List of Threatened Species considers most economic timber species as vulnerable and efforts geared towards their conservation and propagation have become imperative (IUCN, 2006). This requires the production of seedlings of species such as *Terminalia ivorensis and Khaya senegalensis.* Therefore, this study assessed the germination potential and early growth characteristics of the two species in the dryland ecosystem of Kano State, Nigeria.

MATERIALS AND METHODS

The experiment was conducted in the enclosure of an orchard along Bayero University, Kano State, Nigeria. This location is on latitude 12º03`0.0000``N and longitude 8º32`0.0012``E, with the highest altitude (Goron Dutse Hill) at 534 m above sea level (Salami and Salami, 2009). Seeds of *Terminalia ivorensis* were sourced from the Forestry Division of Ondo State Ministry of Environment, while *Khaya senegalensis* seeds were collected from the Aviation Quarters, Fagge Local Government Area in Kano.

Freshly collected seeds of *K. senegalensis* were soaked for 12 hours in water at room temperature. The *T. ivorensis* seeds were initially soaked in boiled water and allowed to cool for 2 hours, before transferring them into cold water and allowed to soak for 12 hours (Salami**,** 2018). One hundred (100) seeds were carefully selected from the treated seed lots per species. These seeds were sown in germination beds containing top soils. The *T. ivorensis* seeds were watered, once in two days (Ibe *et al.,* 2015) to aid rapid expansion and contraction of the seeds and enhance quick reawakening of the embryo to effective germination. However, *K. senegalensis* were watered, daily because of their flexibility to germination at constant moisture. Watering was carried out with 0.25 L of water (Salami, 2018).

The germination (GP) of the seedlings was determined using eqn. 1:

$$GP = \frac{\text{Seeds Germinated}}{\text{Total Seeds}} \times 100 \qquad \text{Eqn. 1}$$

The kinetic models of seed germination were determined to express the Mean Germination Time (MGT), which is a measure of the speed of germination as enumerated by Tompset and Pritchard (1998) in Eqn. 2.

$$MG\ (t) = \frac{\sum ni.ti(days)}{\Sigma n} \quad \text{..... Eqn 2}$$

Where; t = mean germination time in days;
ni = number of seeds germinated on each germination day;
ti = time for the start of germination to the n^{th} observation; and
n = total number of germinated seeds.

Ten seedlings were randomly selected at two weeks after germination for each species. The seedlings were transplanted into 25 cm x 25 cm polythene pots filled with topsoil amended with processed cow dung. These treatments were replicated 4 times under field conditions, while watering was based on the earlier-mentioned specifications. Growth assessments commenced two weeks after transplanting and montly measurments were taken for 4 months.

Biomass assessments were carried out at the end of four months. Two samples were selected from each replicate, thus amounting to 8 seedlings per species. These were carefully uprooted by lowering them in water and carefully removing the soil. Raw-weights were measured and average wet weight was computed using Eqn. 3:

$$AW = \frac{(\sum PW)}{\sum N} \quad \text{Eqn. 3}$$

Where; AW= Average Wet Weight (g)
∑PW = Total Wet Weight (g);
∑N= Total number of seedlings

The seedlings were oven dried at 60^{o}C for 48 hours and then weighed to determine the dry weight. The experimental data were subjected to T-test Analysis to test for differences in the mean values, at $p < 0.05$ level of significance.

RESULTS

Germination of *T. ivorensis* commenced at 30 days after sowing with 47% germination recorded at 2 weeks after the first seedling emergence; while *K. senegalensis* had its first germination 14 days after sowing, with 85% germination 2 weeks after first emergence (Table 1). Mean Germination Time (MGT) of 2 days was recorded for *K. senegalensis*, while *T. ivorensis* had 3.1 days, with the coefficient of variability of the total output as 26.9%, (Table 1).

The mean heights in the 1st, 2nd, 3rd and 4th months were 4.65 cm, 10.05 cm, 15.07 cm, and 19.47 cm for *Terminalia ivorensis* (Table 2). *Khaya senegalensis* seedlings had 5.72 cm, 11.50 cm, 17.25 cm, and 21.42 cm for the concurrent 4 months, respectively (Table 2). The numbers of leaves of *T. ivorensis* were 6.25, 9.78, 13.68, and 13.80, for the 1st, 2nd, 3rd and 4th months, while *K. senegalensis* had 5.20, 7.60, 10.40, and 13.60 respectively (Table 2). The mean basal diameters were as 1.02 mm, 1.70 mm, 2.36 mm and 2.82 mm in the 1st, 2nd, 3rd and 4th months for *T. ivorensis*, while *K. senegalensis* seedlings had 3.50 mm, 7.60 mm, 12.40 mm, and 21.30 mm for mean basal diameters (Table 2). The mean wet weight was 1.29 g; while the dry weight was 0.76 g for *T. ivorensis* (Table 2), while it was 1.43 g and 0.84 g for *K. senegalensis* (Table 3). There was no significant difference in the seedling height ($t = -0.46$ and $p = 0.66$) and number of leaves ($t = 0.85$ and $p = 0.42$). However, the basal diameter significantly differed ($t = -3.09$ and $p = 0.01$).

Table 1. Germination percentages and mean germination time of *Terminalia ivorensis* and *Khaya senegalensis* seeds

Species	MGT (Days)	Germination (%)
Terminalia ivorensis	2.0	47%
Khaya senegalensis	3.1	85%

Table 2. Growth variables of *Terminalia ivorensis* and *Khaya senegalensis* seedlings

Species	1st Month	2nd Month	3rd Month	4th Month
Seedling height (cm)				
Terminalia ivorensis	4.65	10.05	15.07	19.47
Khaya senegalensis	5.72	11.50	17.25	21.42
Number of leaves				
Terminalia ivorensis	6.25	9.78	13.68	13.80
Khaya senegalensis	5.20	7.60	10.40	13.60
Basal diameter (mm)				
Terminalia ivorensis	1.02	1.70	2.36	2.82
Khaya senegalensis	3.50	7.60	12.40	21.30

Table 3. Weights of *Terminalia ivorensis* and *Khaya senegalensis* after four months

Species	Mean wet weight (g)	Mean dry weight (g)
Terminalia ivorensis	1.29	0.76
Khaya senegalensis	1.43	0.84

DISCUSSION

It is estimated that about 200 tropical tree species in West-Central Africa are within the category of being near-threatened to critically endangered (IUCN, 2006). Hence, understanding the germination and propagation techniques of forest tree species is crucial for their conservation and use in the restoration of degraded lands. Moreover, the continuous supply of high-quality tree seeds for propagation is essential for the success of any afforestation or reforestation programme (Sacande and Pritchard, 2004; Amponsah *et al.*, 2018).

Germination treatments and growth observations are essential in the development of robust propagation procedures for tropical hardwoods. The results corroborate the findings of Agboola *et al.* (2006) who

reported highest germination for *T. ivorensis* in topsoil. Omokhua *et al.* (2015) reported the highest germination in sawdust indicating that media may not be a limiting factor to germination for *T. ivorensis*. The low germination rates recorded for *T. ivorensis* may, be attributed to the impermeable seed coat (McDonald and Omoruyi, 2003).

Furthermore, higher height, basal diameter, and biomass observed for *K. senegalensis* may not be attributed to the ability of the species to thrive well in its native range of dryland ecosystems. *Khaya senegalensis* produces leaflets while *T. ivorensis* produces simple leaves and these morphological differences play a role in the physiology of the plants. *Terminalia ivorensis* is a deciduous plant that responds to the changing climatic conditions through shedding of leaves. On the other hand, *K. senegalensis*is is an evergreen species and this allows it to cope under stressful climatic conditions (Omokhua*et al.,* 2015; ICRAF, 2016). This was observed in the biomass accumulated by both species (Hassan and Ali, 2013; Adegoke *et al.,* 2014).

Additionally, Adegoke *et al.* (2014) reported the early growth of *T. ivorensis* at after 16 weeks and observed that height ranged from 19.4 cm and 21.33 cm; basal diameter varied from 2.83 mm to 3.22 mm, while number of leaves increased from 13.70 and 14.98. This are similar to the findings in this study (height = 19.47cm; number of leaves = 13.8 and basal diameter = 2.82 mm). Hassan and Ali (2013) also reported early growth of three provenances of *K. senegalensis* after 3 months. The height ranged from 14 cm and 16 cm. This corresponds to the results of this experiment (13.97 cm).

CONCLUSION

Terminalia ivorensis and *Khaya senegalensis* were able to germinate and grow under nursery conditions in the dryland of Nigeria. Howbeit, improved seed treatment methods are required to increase the germination success of *T. ivorensis.* The species are recommended for large-scale production and could help fill the gaps in timber production through plantation establishment, afforestation and reforestation.

REFERENCES

Adegoke, F., Akinyele, A. and Ogunwande, O. (2014). Effect of seed size and source on early seedling growth of *Terminalia ivorensis* (Chev.). *Agriculture and Forestry* 60 (2): 157-166.

Agboola, D. A., Idowu, W. F. and Kadiri, M. (2006). Seed germination and seedling growth of the Mexican sunflower *Tithonia diversifolia* (Compositae) in Nigeria, Africa. *International Journal of Tropical Biology* 54(2): 385-402.

Alamu, L. O. and Alabi, A. (2015). Influence of temperature differentials on germination and growth of *Terminalia ivorensis* (A. Chev). *Science Research* 3(6): 296-299.

Amponsah, J. O., Maaleku, B. K., Djagbletey, G. D., Asomaning, J.M., Debrah, D. K., Kumah, F. and Tandoh, P. K. (2018). Phenology and seed germination improvement of *Terminalia superba* and *Terminalia ivorensis* in a moist semi-deciduous forest in Ghana. *Ghana Journal of Forestry* 34 (1): 1–14.

Borokini, T. I., Onefeli, A. O., Babalola, F. D. (2013). Inventory analysis of *Milicia excels* (Welw C. C. Berg) in Ibadan (Ibadan Metropolis and University of Ibadan), Nigeria. *Journal of Plant Studies* 2 (1): 97-109.

Dorthe, J. and Sylvie, G. (2003). *Khaya senegalensis* (Desr) - Taxonomy and nomenclature. Seed Leaflet No. 66.

Gbadebo, J. O. and Salami, A. O. (2008). Effects of pre-treatment on seed germination and seedling emergence of *Tamarindus indica* (Linn). *Journal of Sustainable Environmental Management.* 1 (1): 24-28.

Hassan, F. A. and Ali, M. M. (2013). Environmental conditions prevailing in habitat affects seedlings growth (*Khaya senegalensis*). *International Journal of Scientific and Research* 3(3).

Haysom, K. and Murphy, S. (2003). The status of invasiveness of forest tree species outside their natural habitat: A global review and discussion Paper. Rome, Italy: FAO. http://www.fao.org/DOCREP/006/J1583E/J1583E00.htm . Retrieved 20/11/2015.

Ibe, A. E., Adeyemi, A. A., Nwuda, B. N., Asiabaka, C. C. and Onuoha, G. N. (2015). Seed germination and seedling growth of *Terminalia ivorensis* (A. Chev) in different growth media. *FUTO Journal Series* 1:(2): 138-145.

ICRAF, (2016). *Khaya senegalensis* (Desr.) A. Juss. International Centre for Research in Agroforestry.

IUCN, (2006). Red list of threatened species. International Union for the Conservation of Nature.

Jegede, O. C., Onefeli, A. O., Gbadebo, J. O., and Adeniji, I. (2020). Biomass accumulation of selected indigenous species under flood condition. *Journal of Forestry Research and Management* 17(3): 14-21.

Keay, R. W. J. (1989). Trees of Nigeria. A revised edition, Clarendon Press Oxford.

McDonald, I. and Omoruyi, O. (2003). Effect of seed pre-treatment on germination of two surface types of *Dialium guineense*. *Seed Technology* 25: 41-44.

Omokhua, G. E., Ogu, A., and Oyebade, B. A. (2015). Effects of different sowing media on germination and early seedling growth of *Terminalia ivorensis* (A. Chev). *International Journal of Scientific and Technology Research* 4: 119-122.

Onefeli, A. O. and Adesoye, P. O. (2014). Early growth assessment of selected exotic and indigenous tree species in Nigeria. *South-East European Forestry* 5 (1): 45-51.

Onefeli, A. O. and Agwu, P. O. (2015). Prospect of *Milicia excelsa* (Welw.) C. Berg for Multi-tree species Agroforestry. *South-East European Forestry* 6 (2): 249-256.

Onefeli, A. O. and Akinyele, A. O. (2014). Macropropagation of *Dennettia tripetala* Baker f. *South-East European Forestry* 5 (2): 135-144.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. (2009). Agroforestry database: A tree reference and selection guide. Version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp- Retrieved 20/11/2015.

Quedraogo, A. S., Thomsen, K., Engels, J. M. and Engelmann, F. (1999). Recalcitrant seeds. *Forest Seed Science and Technology* 28: 227-234.

Sacande, M. and Pritchard, H. W. (2004). Seed research network on African trees for conservation and sustainable use. *Forest Genetic Resources* 31: 313 - 325.

Salami, A. O. (2018). Pre-germination treatments of some indigenous Sudan savannah tree species in Nigeria. A Dissertation Report for M.Sc. Award. Department of Geography, Faculty of Earth and Environmental Sciences, Bayero University, Kano.

Salami, A. O. and Salami, N. T. (2009). Effects of concentrated hydrochloric acid (HCl) and water pre-treatments on seed germination and seedling emergence of *Adansonia digitata* (Linn). *Journal of Agricultural Technology and Rural Development* 1 (1): 44-51.

Smith, N., Scott, A. M., Henderson, A., Stevenson, D. V. and Scott, V. H. (2004). Flowering plants of the tropics. Princeton University Press, Princeton, New Jersey. Pp. 105.

Tompset, P. B. and Pritchard, H. W. (1998). The effect of chilling and moisture stress on germination, desiccation tolerance and longevity of *Aesculus hippocastanum* L. seeds. *Annals of Botany* 82: 249-261.