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Early Growth Rate Disparity in Indigenous and Exotic Tree Species in Nigeria

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ABSTRACT

The hypothesis that exotic trees have a fast growth rate and a very short gestation period could be responsible for their preference as plantation species in Nigeria. However, research to ascertain this hypothesis has been limited to a very few indigenous tree species. In this study, early growth rate disparity (GRD) between nine indigenous and two exotic tree species were compared. The seedlings used for this study were obtained from the Forestry Research Institute of Nigeria (FRIN) Ibadan and Ondo State Forestry Department, Akure. The seedlings were randomly planted on a well-prepared site at Federal University of Technology, Akure (FUTA) using a 3m × 3m espacement with 10 replicates per species. Their initial height, collar diameter and the number of leaves were recorded. The growth characteristics of the seedlings (total height, collar diameter and the number of leaves) were monitored and enumerated fortnightly for six months. The data collected were subjected to the analysis of variance (ANOVA) and means were separated with Duncan New Multiple Range Test. In this study, the total height was found to be significantly higher in *Gmelina arborea* (64.14cm), followed by *Ceiba pentandra* (45.84cm), *Tectona grandis* (42.53cm) and *Adansonia digitata* (38.02cm). *T. grandis* had the highest diameter growth (3.88cm), followed by *G. arborea* (3.65cm), *C. pentandra* (3.23cm) and *Cordia millenii* (3.22cm). However, the number of leaves recorded for *A. digitata* (52.96) was significantly higher than the number of leaves recorded for the exotic tree species. *G. arborea* was found to be 28.53% faster in height growth than *C. pentandra*. It was 33.69%, 40.72%, 43.69%, 55.85%, 57.61%, 74.51%, 75.41%, 75.58% and 86.61% faster in height growth than *T. grandis*, *A. digitata*, *Nauclea didderichii*, *Triplochiton scleroxylon*, *C. millenii*, *Khaya senegalensis*, *Mansonia altisima*, *Terminalia superba* and *T. africana*, respectively. *C. pentandra*, the second best after *G. arborea*, was found to be 7.22% and 17.06% faster in height growth than *T. grandis* and *A. digitata*. The growth disparities among the tree species could be attributed to their genetic makeup. Therefore, efforts should be geared towards enhancing the growth rate of indigenous tree species.

Keywords: Forest trees, Growth disparity, Indigenous species, Exotic species, Genetic makeup.

Introduction

Forest resources are naturally endowed renewable resources and Nigeria is enormously gifted with these resources (Ijeoma and Aiyeloja, 2010). Forest resource provides some basic needs of life such as food, shelter, clothing, fuel wood, soil fertility, conservation of land and so on. For this reason, forest resources play a crucial role in human development. Everybody depend on forest resources directly or indirectly. For instance, tree is one of the important components of forest ecosystem and is a part of nature's precious gifts. Trees represent a huge natural resource used for the production of paper, fuel and furniture.

Trees serve as a sink for atmospheric carbon emitted to the atmosphere through various sources such as bush burning, fumes and smoke from houses, industries and automobile. The absence of forest trees will permit the escape of these gases to the atmosphere which then have the potential to deplete the ozone layer and capable of aggravating global warming. As trees grow and their biomass increases, they absorb carbon from the atmosphere and store it in the plant tissues resulting in growth of different parts (IPCC, 2006). Plants take CO_2 from the atmosphere. Then, through the process of photosynthesis, the energy is trapped in the organic molecules and used by the plants themselves. During this process, a number of organic substances are stored as constituents of the standing tree, most of which is eventually added to the soil as plant organic litter and then to the soil as soil organic carbon (SOC) by microbial activities.

In forest ecosystems, tree species could be classified as indigenous and exotic species. A tree is regarded as indigenous species if it is naturally endemic to a given region or nation without human intervention. However, a tree is termed exotic tree species if it is being cultivated outside its natural region. According to Ijeoma and Aiyeloja (2010), there are abundant native tree species with timber value than the exotic species. Asides from their timber values, indigenous tree species help to preserve the nation's cultural and social values but are perpetually threatened or abandoned.

The cardinal reason why exotic trees are preferred to the indigenous trees as plantation species in Nigeria could be traced to the hypothesis that the indigenous tree species have slow growth rate and a very long gestation period. However, research to ascertain this hypothesis has been limited to very few indigenous tree species. Therefore, this research was designed to compare the early growth rate of some indigenous and exotic tree species in Nigeria.

Materials and Methods

Study area

The study was carried out at the plantation site of the Department of Forestry and Wood Technology, Federal University of Technology Akure, Ondo State Nigeria. The study area is located between Latitude $7^0$09'N and $7^0$19'N of the equator and Longitude $5^0$07'E to $5^0$17'E of the Greenwich meridian (Ojo *et al*., 2014).The climate of the study area is of the Southwest monsoon, experiences a warm humid lowland tropical climate with wet and dry seasons. The mean annual rainfall with bimodal rainfall pattern is about 1500m with a short August break. The rainy or wet seasons normally starts from April to October, last for about seven months. The dry season characterized with cool wind of harmattan, normally starts from November to March. During the harmattan (December to February), the daily average temperature is about 22^0C and 32^0C in March with little variation throughout the year.

Data Collection

The seedlings used for this study were obtained from Ondo State Forestry Department Akure, Ondo State, Nigeria and Forestry Research Institute of Nigeria (FRIN) Ibadan, Oyo State, Nigeria. Nine indigenous and two exotic tree species were used in this study.The indigenous species include: *Khayyam senegalensis, Adansonia digitata, Nauclear diderrichi, Mansonia altisima, Triplochyton scleroxylon, Treculia africana, Cola millenii, Terminalia superba*, and *Ceiba pentandra*. The exotic tree species are

Tectona grandis and *Gmelina arborea*. Ten (10) seedlings of each species at eight months were selected for planting. The experiment was arranged in a Completely Randomized Design (CRD). The seedlings were transplanted at 3m×3m spacing on the field.Their growth variables: seedling height, collar diameter and number of leaf were recorded fortnightly for six months. Visual counting was used for the number of leaves, Vernier caliper and 50 cm ruler were used to measure the collar diameter and the seedling height respectively.

Data Analysis

The cumulative seedling height, collar diameter and number of leaves were plotted on a graph. Individual seedling data for collar diameter (cm), tree height (cm) and number of leaves were subjected to one-way analysis of variance (ANOVA). Where a significant difference exists, Duncan multiple range test was used for post-hoc analysis. Percentage growth rate between species was computed as:

$$\% \text{ Growth Rate} = \frac{\text{Height defference between species}}{\text{Height of the tallest species}} \times 100$$

Results

The cumulative curve for seedling height of the entire tree species used in this study is presented in Figure 1. Two weeks after planting on the field, *T. grandis* increased with an average height of 5.04cm and was the highest of all the selected species. This was followed by *C. pentandra* (4.87cm), *G. arborea* (4.48cm), *T. scleroxylon* (3.87cm), *A. digitata* (3.30cm), *C. millenii* (2.99cm), *K. senegalensis* (2.94cm), *N. diderichii* (2.04cm), *M. altisima* (1.53cm), *T. superba* (1.10cm) and *T. africana* (0.93cm) which had the least average height increment. This increment followed the same pattern until eight weeks after planting when *G. arborea* overtook all other species with average cumulative height of 28.49cm.This was closely followed by *C. pentandra* (28.19cm), *T. grandis* (23.53cm), *A. digitata* (19.21cm), *T. scleroxylon* (15.23cm), *C. millenii* (14.82cm), *N. diderichii* (13.97), *K. senegalensis* (12.65), *T. superba* (11.59cm) and the least average cumulative height was recorded for *T. africana* (3.89cm). Moreover, at the final assessment of the seedling height, *G. arborea* had the highest average height (64.14cm). This was closely followed by *C. pentandra* (45.84cm), while the tree species that had the least height increment was *T. africana* (8.59cm).

Two weeks after planting, *T. grandis*, had the highest mean collar diameter increment (3.88cm) and *T. africana* had the lowest mean collar diameter increment (0.86cm), Six months after planting, *T. grandis* had the highest mean collar diameter (10.87cm) followed by *Cola milleni* (10.02cm) and *Gmelina arborea* (8.78cm) as presented in the Figure 2.

Figure 3 revealed the periodic changes in the number of leaves from when they were planted to six months after planting. *A. digitata* (52.96) had the highest number of leaves in this study. This was followed by *G. arborea* (36.90), *T. superba* (21.52), *T. scleroxylon* (9.70), *C. pentandra* (9.50), *C. millenii* (9.25), *K. senegalensis* (6.51), *T. grandis* (4.77), *N. diderrichii* (4.58), *T. africana* (3.37) and *M. altisima* (2.08) had least number of leaves.

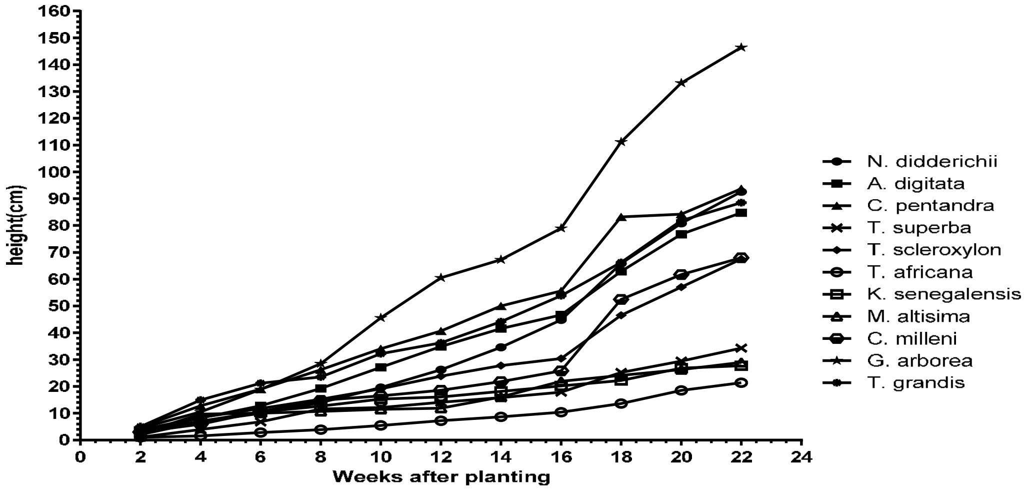

Figure 1: Cumulative mean collar diameter for indigenous and exotic tree species investigated

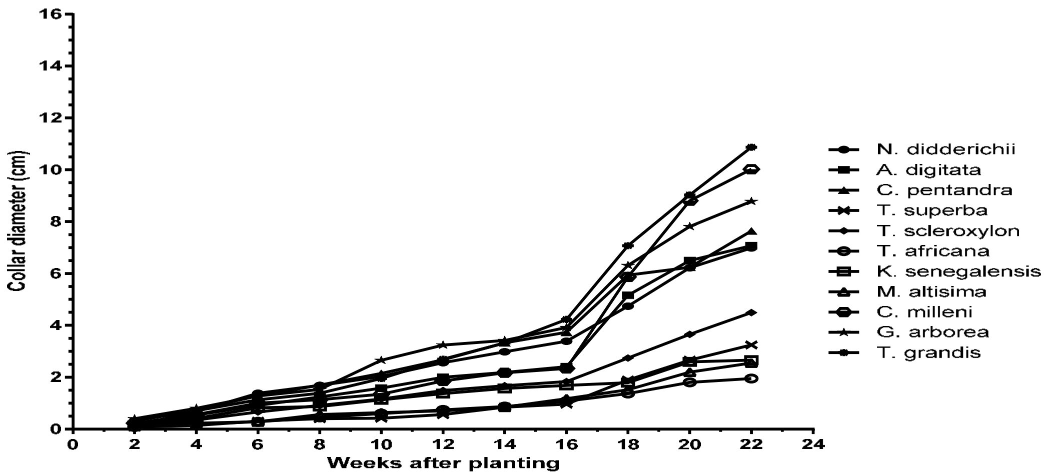

Figure 2: Cumulative mean collar diameter for indigenous and exotictree species investigated

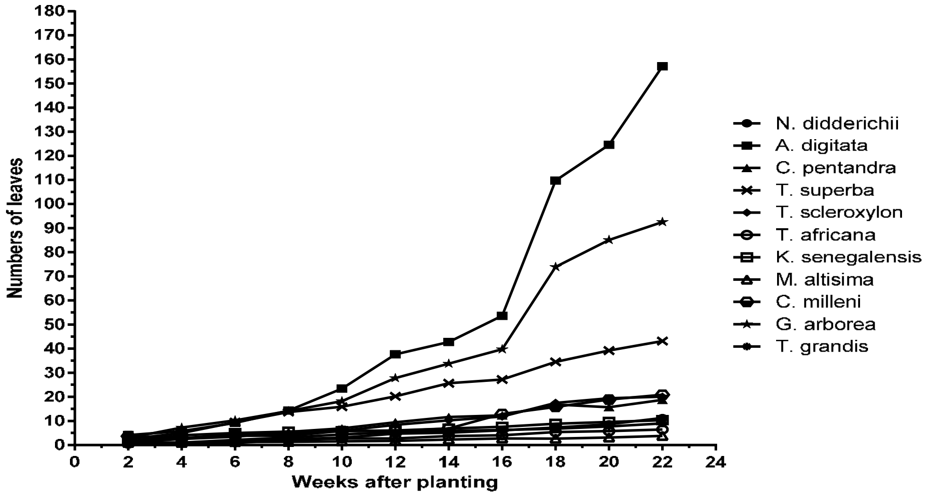

Figure 3: Cumulative mean of the number of leaves of indigenous and exotic tree species

Percentage difference in the seedling's height growth among the selected species is presented in Table 1. Comparing height growth between the exotic species, it was discovered that *Gmelina arborea* was 33.7% faster than *Tectona grandis* and 28.5% faster than the fastest indigenous tree species (*Ceiba pentandra*) investigated in this study. *Ceiba pentandra* was found to be 7.2% faster than *Tectona grandis, an exotic species. Tectona* The Duncan New Multiple Range Test for separating the mean difference in the growth variables among the species investigated is presented in Table 2. The highest height growth was recorded for *Gmelina arborea.* Height growth in *Ceiba pentandra* (45.84cm) was not significantly different from *G. arborea* (64.14cm) but significantly different from *Adansonia digitata* (38.02cm). *grandis*, one of the most populous plantation species in Nigeria, was discovered to be 33.4% faster in height growth than *Triplochiton scleroxylon*, an indigenous tree species believed to have a fast growth rate. However, *Triplochiton scleroxylon* was found to be 44.3% faster than *Terminalia superba*. *Nuclea didderichii* was also found to be 21.6% faster than *Triplochiton scleroxylon.*

Considering the diameter growth of the seedlings, there was no significant difference between *Tectona grandis* (3.88cm) and *Gmelina arborea*(3.65cm). The tree seedling with the highest mean leaf production was *Adansonia digitata* (52.96). This was followed by *Gmelina arborea*(36.90) and *Terminalia superba* (21.52) as presented in the Table 2.

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Table 1: Percentage (%) difference in seedling's height growth among the studied tree species

Species	*G. arborea*	*C. pentandra*	*T. grandis*	*A. digitata*	*N. didderichii*	*T. scleroxylon*	*C. millenii*	*K. senegalensis*	*M. altisima*	*T. superb*	*T. africana*
G. arborea											
C. pentandra	28.53										
T. grandis	33.69	7.22									
A. digitata	40.72	17.06	10.6								
N. didderichii	43.69	21.2	15.07	5							
T. scleroxylon	55.85	38.22	33.41	25.51	21.59						
C. millenii	57.61	40.68	36.07	28.49	24.72	3.99					
K. senegalensis	74.51	64.33	61.56	57	54.73	42.27	39.87				
M. altisima	75.41	65.6	62.92	58.52	56.34	44.31	42	3.55			
T. superba	75.58	65.84	63.18	58.81	56.64	44.7	42.41	4.22	0.7		
T. africana	86.61	81.26	79.8	77.41	76.22	69.67	68.41	47.46	45.53	45.15	

Table 2: Growth rate disparities among the selected species

S/No	Species	Height increment (cm)	Collar diameter increment (cm)	Number of leaves (n)
1	*Adansoniadigitata*	38.02[c]	2.70[abc]	52.96[a]
2	*Ceibapentandra*	45.84[ab]	3.23[ab]	9.50[c]
3	*Cola millenii*	27.19[cd]	3.22[ab]	9.25[c]
4	*Khayasenegalensis*	16.35[cd]	1.37[bc]	6.51[c]
5	*Mansoniaaltisima*	15.77[cd]	.99[c]	2.08[c]
6	*Naucleadidderichii*	36.12[bc]	2.98[abc]	4.58[c]
7	*Terminalia superb*	15.66[cd]	1.05[c]	21.52[bc]
8	*Triplochytonscleroxylon*	28.32[bcd]	1.73[abc]	9.70[c]
9	*Treculiaafricana*	8.59[d]	.86[c]	3.37[c]
10	*Gmelinaarborea*	64.14[a]	3.65[a]	36.90[ab]
11	*Tectonagrandis*	42.53[ab]	3.88[a]	4.77[a]

Means with similar superscript within the same column are not significantly different at p=0.05.

Discussion

The early growth rate of the selected tree species varied concerning seedling height, collar diameter and number of leaves. The significant difference observed in the seedlings growth rate could be due to differences in their genetic make-up which could affect their various abilities to adapt to the same environmental condition. It could also be a combined effect of the environment and the intrinsic characteristics of tree species, which determines their physiognomy (Nwoboshi, 1982). This study revealed that *Gmelina arborea*, an exotic tree species, had faster height growth ability than *Tectona grandis* and the other indigenous species used in the study. This finding is in support of Adekunle (2006), who stated that teak grows slower than *Gmelina arborea* but it has a longer life span.

Tree growth rate may be affected by the wood density. That is, a highly dense wood may grow slower than a tree with low density. For instance, the wood density of *Gmelina arborea* (450kg/m^3) is relatively small when compared with the wood density of *Tectona grandis* (660kg/m^3).Other indigenous tree species may possibly have higher wood density, hence their slow growth.However, the relationship between wood density and tree growth has been controversial (Chen *et al.*, 2017). While Deng *et al.*, (2014) and Zhang *et al.*, (2012) reported apositive relationship between wood density and diameter at breast height (dbh) for *P. massoniana*, Osunkoya*et al.*, (2007) discovered a negative relationship between wood density and dbh for 27 tree species in a tropical rainforest on Borneo Island.Phillips *et al.*, (2003) opined that trees may increase stem hydraulic conductance for fluid transport to service increasing living biomass when they get taller such that wood density is negatively correlated with maximum tree height (Thomas, 1996). Also, many studies had since shown that the wood density is also closely related to the survival and growth rates of species under strong selective pressure in their environment (Falster, 2006; King *et al.*, 2005; Preston *et al.*, 2006).

The slow growth rate of indigenous tree species used in this study could be improved through selection and breeding. Following the suggestion of Namkoong *et al*. (1980) that only genotypes whose phenotypes approximate the population mean are good for selection while those below should be at a disadvantage. Silva *et al.* (2008) opined that selection becomes a more effective tool in genetic improvement when all traits of economic importance are evaluated. Genetic engineering is another method to increase the growth rate of indigenous tree species. Etchells *et al.* (2015) successfully modified two genes responsible for the rate of cell division in poplar trees, called PXY and CLE. According to them, overexpression of the genes resulted in the trees growing twice as fast as normal.

Conclusion and Recommendation

There was growth disparity among the selected species. Exotic tree species performed better in terms of height and diameter than the selected indigenous tree species. *A. digitata* had the highest leaves production than the exotic species. Since the results of this study showed that selected exotic tree species had superior growth characteristics than the selected indigenous tree species, it is therefore recommended that frantic efforts be put in place to improve the growth rate of the indigenous tree species considering their economic and environmental importance.

References

Adekunle, V. A. J. (2006).Conservation of tree species diversity in tropical rainforest ecosystem of south-west Nigeria. *Journal of Tropical Forest Science* 18(2): 91–101

Chen L.Wenhua Xiang W., Wu H., Lei P., Zhang S., Ouyang S., Xiangwen Deng X. and Fang X. (2017). Tree growth traits and social status affect the wood density of pioneer species in secondary subtropical forest. *Ecology and Evolution.* 7:5366–5377.

Deng X., Zhang L., Lei P., Xiang W., & Yan W. (2014). Variations of wood basic density with tree age and social classes in the axial direction within *Pinusmassoniana* stems in southern China. *Annals of Forest Science*,71(4), 505–516.

Etchells J.P., Mishra L.S., Kumar M., Campbell L., Turner S.R. (2015). Wood Formation in Trees Is Increased by Manipulating PXY-Regulated Cell Division. *Current Biology* Volume 25, ISSUE 8, P1050-1055.DOI:https://doi.org/10.1016/j.cub.2015.02.023

Falster D. S. (2006). Sapling strength and safety: The importance of wood density in tropical forests. New Phytologist, 171(2), 237–239.

Ijeomah HM, Aiyeloja A. A. (2010). Ecotourism: An instrument for combating Renewable Natural Resources Degradation. *In*: Ijeoma, H. M., Aiyeloja, A. A., (*eds*) Practical Issues in Forest and wildlife Resources management. Green canopy consultants, Choba, Port Harcourt, Nig. 625p.

Intergovernmental Panel on Climate Change (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme (eds Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K.). Institute for Global Environmental Strategies, Japan.

King D.A., Davies S.J., Supardi M.N.N., Tan S.(2005). Tree Growth is Related to Light Interception and Wood Density in two

Mixed Dipterocarp Forests of Malaysia. *Functional Ecology*. 19:445–453

Namkoong G., Barnes R.D. and Burley J. (1980). Selecting for yield in forest tree breeding. *Common wealth For. Rev*. 59(1):61-68.

Nwoboshi L.C. (1982). Tropical Silviculture: Principles and Techniques. Ibadan Univ. Press, Ibadan, Nigeria, 333 p

Ojo J. S., Olorunfemi M. O., Bayode S., Akintorinwa O. J., Omosuyi, G. O., and Akinluyi, F. O. (2014). Constraint Map for Landfill Site Selection in Akure Metropolis, Southwestern Nigeria. *Ife journal of science*. 16(2): 405-416p.

Osunkoya O., Sheng T., Noraziah M., andNorhazlyna D. (2007). Variation in wood density, wood water content, stem growth and mortality among twenty-seven tree species in a tropical rainforest on Borneo Island. *Austral Ecology*, 32(2), 191–201.

Phillips N. G., Ryan M. G., Bond B. J., McDowell N. G., Hinckley T. M., &Cermák J. (2003). Reliance on stored water increases with tree size in three species in the pacific northwest. *Tree Physiology*, 23(4), 237–245.

Preston K. A., Cornwell W. K., andDeNoyer J. L. (2006). Wood density and vessel traits as distinct correlates of ecological strategy in 51 California coast range angiosperms. *New Phytologist*, 170(4), 807–818.

Silva F.F., Pereira M.G., Ramos H.C.C., Junior P.C.D., Pereira T.N.S.P., Gabriel A.P.C., Viana A.P., Ferreguetti G.A. (2008). Selection and estimation of the genetic gain in segregating generations of papaya (*Carica papaya* L.). *Crop Breed. Appl*. *Biotechnol*. 8:1-8.

Thomas S. C. (1996). Asymptotic height as a predictor of growth and allometric characteristics in Malaysian rain forest trees. *American Journal of Botany*, 83(5), 556–566.

Zhang L. Y., Deng X. W., Lei X. D., Xing W. H., Peng C. H., Lei P. H., & YanW. D. (2012). Determining stem biomass of *Pinusmassoniana* L. through variations in basic density. Forestry, 85(5), 601–609.