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Influence of Climate, Seed Sizes and Land Use Types on the Germination and Early Growth of Garcinia kola and *Cola nitida* in Nigeria

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Abstract

Garcinia kola and *Cola nitida* are important multipurpose economic tree species in Nigeria that have the potentials to contribute to the regional and local income generation of the rural people. The cultivation of both species is very much limited in Nigeria; they can contribute immensely to the livelihood of the rural dwellers. The study was carried out to investigate the impact of climate, seed sizes and land use types on germination and survival of *G. kola* and *C. nitida* with the view to ascertain and provide baseline information of appropriate seeds sources to ensure successful propagation of *G. kola* and *C. nitida* in Nigeria. A factorial experiment in completely randomized design was used. A total of 1500 seeds each of *G. Kola* and *C. nitida* were used for study. Twenty seeds of uniform sizes were carefully selected and sorted for each seed class of the two species and were used for each treatment and replicated five times. The data were analyzed using descriptive statistic, Analysis of Variance (ANOVA) and Principal Component Analysis (PCA). The results indicated that seeds sizes and land use types significantly influence the germination percentage of both *G. kola* and *C. nitida*, the larger the seed size of *G. kola* and *C. nitida* the more the germination percentage. The PCA also confirm that germination and growth parameter assessed (height and collar diameter) are positively correlated with big seeds which implies that the seed sizes significantly affected germination and early growth variables of the two species, the protected area and agroforestry plots looks more appropriate for propagation because they positively correlated with the germination percentage and early growth variables unlike seeds from compound farm that are characterize with low germination percentage and low growth rate. The study has shown that seed sources and seed morphological characters had significant influence on the germination and early growth performance of *G. kola* and *C. nitida*.

Keywords: Germination; Protected area; Agroforestry; Garcinia kola; *Cola nitida*

Abbreviations: PCA: Principal Component Analysis; CRD: Completely Randomized Design; FRIN: Forestry Research Institute of Nigeria

Introduction

The economies of African countries are largely based on weather-sensitive agricultural and forest fruits productions systems which are vulnerable to climate change. Nigeria is a country with a marked ecological diversity and occupies a unique geographic position in Africa with variability in climate and geographic features [1]. Pressure from growing populations has results in diminishing the natural resources, further threatening food production, instability of climatic conditions, and increase in poverty with people unable to live in their homes and their sources of income destroyed [2].

Garcinia kola Heckel usually called bitter kola, is an indigenous medicinal tree belonging to the family Guttiferae. It is an evergreen tree species found in forests throughout West and Central Africa [3]. It is one of the most important trees species valued in Nigeria for its medicinal usefulness which has led to the over exploitation of this species in the natural forests [4]. The genus Cola (Malvaceae) comprises of numerous tree species which mainly occur in African rainforests. It is represented by over 40 species in West Africa, with two species (*C. acuminata* and *C. nitida*) being cultivated for their seeds (kola nuts) in Nigeria. However, *Cola nitida* (Vent.) Schott & Endl is the only kola nut that is important for inter-regional and international trade [5].

The natural regeneration of *G. kola* is poor, and seedlings are uncommon and slow-growing [6,7], making the species now close to commercial extinction [8,9]. *G. kola* is listed as one of the priority species for immediate conservation action in sub-Saharan forests, and hence, therefore, its suitable seed sources are essential.

The cultivation of *G. kola* and *C. nitida* is very much limited in Nigeria [10]. Most of the productive *G. kola* trees are those which were left standing when farm plots were cut out of the forest [11], and populations are seriously shrinking. There is no information on the impact of climate gradients and land use type on the germination and growth of this species. There is therefore the need to undertake studies aimed at providing information for conservation of the species by small scale farmers through agroforestry systems.

It is necessary to initiate studies aimed at getting insights on multipurpose tree species such as *G. kola* and *C. nitida* on the influences of individual trees ecology on germination. Information on seed sources is vital in ensuring successful cultivation, establishment of plantations, conservation options and their inherent agro-ecosystems services.

Materials and Methods

Study area

The study was carried out in the Screen house of Silviculture Nursery at the Department of Sustainable Forest Management, Forestry Research Institute of Nigeria (FRIN) located on the longitude 07023'18''N to 07023'43''N and latitude 03051'20''E to 03051'43''E. The climate of the study area is the West African monsoon with dry and wet seasons. The dry season is usually from November through March and is characterized by dry cold wind of harmattan. The wet season usually starts from April to October with occasional strong winds and thunderstorms. Mean annual rainfall is about 1548.9mm, falling within approximately 90 days. The mean maximum temperature is 31.9 °C, minimum 24.2 °C while the mean daily relative humidity is about 71.9% [12].

Seeds collection

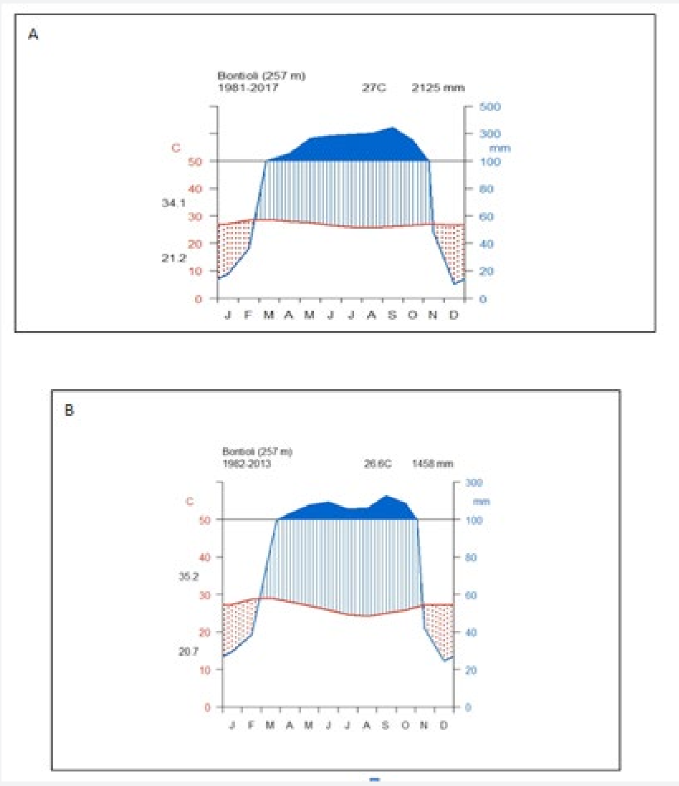

Figure 1: Climate diagram of the study area. A= rain forest zone, B= derived savanna area from data collected at metrological station from the period 1981-2017.

Matured fruits of *G. kola* and *C. nitida* were collected from the mother trees from two vegetation zones in Nigeria namely, rainforest areas and derived (Rivers,Ondo and Abia states) savanna (Enugu, Ekiti and Osun states) and each of these areas is characterized by unique vegetation and climatic attributes (Figure 1).

Extraction and processing of *G. Kola* and *C. nitida* seeds

The seeds of *G. Kola* were extracted from the pulp, washed and air dried at room temperature for three (3) days. *G. Kola* seeds were decoated and subjected to soaking in water for 72 hours as recommended by [13], the seeds were sorted to different seeds sizes (small, medium and big), the seeds of *C. nitida* were extracted from the pulp and washed and soaked in water for 24 hours to break the dormancy.

Experimental procedure

To investigate the influence of the climatic gradients on the germination of the species, a total of 600 seeds *G. kola* and 600 seeds of *C. nitida* were used for this study. One hundred (100) seeds of uniform sizes were selected from each seed size from the two species in two climatic gradients namely; rain forest areas and derived savannah areas. To influence of land use types on the germination of the species, a total of 900 seeds *G. kola* and

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900 seeds of *C. nitida* were collected from three land use type (protected area, agroforestry plots and compound farm) and were used for study. One hundred (100) seeds of uniform sizes were selected from each seed size of the two species from three land use types. Twenty (20) seeds were used for each treatment and replicated five times. Sterilized river sand was used as the sowing medium for this experiment. The seeds were sown into germination trays filled with river sand. The germination trays were placed in a non-mist propagator. Watering was done with the aid of a watering can. Germination was monitored every day.

Experimental design and data analysis

To investigate the influence of the climatic gradients on the germination of the species, the data was analysis using analysis of variance (ANOVA) using 2x3 factorial experiment in completely randomized design (CRD). Factor 'C' is climatic gradient (rain forest areas and derived savanna areas) while Factor 'S' is Seed sizes (small, medium and large). To influence of land use types on the germination of *G. kola* and *C. nitida*, analysis of variance (ANOVA) was used and laid in 3x3 factorial experiments in CRD. Factor 'L' is Land use type (Protected area, Agroforestry plot and Compound farm) while Factor 'S' Seed sizes (small, medium and large) and Principal component analysis was used to check the correlation between seed sizes, germination and early growth variables.

Results

Table 1: Mean Table for Effects of Climatic Gradient and Seed Sizes on the Germination Percentage of *G. kola* and *C. nitida* Seeds.

Climatic Gradient	Seed Sizes	G. kola	C. nitida
		Mean±SD	Mean±SD
Forest Zone	Small	31.00±13.47c	40.44±20.62c
	Medium	55.08±18.09b	58.55±18.49b
	Large	65.00±18.69a	78.22±9.48a
	Total	50.36±21.89	59.07±22.60
Derived Savannah area	Small	29.16±13.12c	40.33±20.76c
	Medium	55.83±18.93b	57.66±17.80b
	Large	65.50±18.68a	78.11±10.45a
	Total	50.16±22.78	58.70±22.61

Mean ± SD with the same alphabet in the column are not significantly different (p≤0.05)

Germination of C. nitida seeds started two weeks after sowing, while that of G. kola started five weeks after sowing for seeds collected from both different climatic gradients and land use types. Result on monthly germination percentage assessment showed that there was increase in the germination of *G. kola* and *C. nitida* seeds collected from both rain forest areas and derived savannah areas. Rain forest areas had mean germination percentage of 50.36% for G. kola (Table 1) while derived savannah areas had a mean germination of 50.16%. Considering seeds collected from rain forest areas, large seeds of *G. kola* gave the highest germination % of 65.00% while small seeds of *G. kola* gave the lowest germination % of 31.00%. Large seeds of *C. nitida* gave the highest germination% of 78.22% while small seeds of *C. nitida* gave the lowest germination % of 40.44%. Considering seeds collected from derived savannah areas, large seeds of *G. kola* gave the highest germination % of 65.50% while small seeds of *G. kola* gave the lowest germination % of 29.16%. Large seeds of *C. nitida* gave the highest germination % of 78.70% while small seeds gave the lowest germination % of 40.33% respectively.

Result of Analysis of Variance (ANOVA) revealed that climatic gradient did not significantly affect the germination percentage of both *G. kola* and *C. nitida* seeds (Table 2), seed sizes significantly affected the germination % of both species while there was no interaction effect of climatic gradient and seed sizes on the germination % of *G. kola* and *C. nitida* respectively (Table 2). Mean separation result showed that the germination % of large seeds of *G. kola* collected from both rain forest areas and derived savannah areas were not significantly different from each other, germination % of medium seeds of *G. kola* seeds collected from both rain forest areas and derived savannah areas were not also significantly different from each other while germination % of seeds of *G. kola* collected from both rain forest areas and derived savannah areas were not significantly different from each other (Table 1). This is also applicable to the vary seed sizes of seeds of *C. nitida* collected from both rain forest areas and derived savannah areas (Table 1).

Table 2: ANOVA Table for Influence of Climatic Gradient and Seed Sizes on the Germination Percentage of *G. kola* and *C. nitida* Seeds.

Source of Variation	G. kola		C. nitida	
	df	Sig.	Df	Sig.
Location (L)	1	0.96ns	1	0.93ns
Seed sizes (S)	2	0.00*	2	0.00*
L * S	2	0.96ns	2	0.99ns
Error	66		48	
Total	71		53	

*- significant (p<0.05); ns-not significant (>0.05)

Result on monthly germination percentage assessment showed that there was increase in the germination percentage of *G. kola* and *C. nitida* seeds collected from protected area, agroforestry plots and farm land respectively. The seeds of *G. kola* collected from protected area had the highest mean germination% of 51.66% while seeds of *G. kola* collected from farm land had the lowest germination % of 32.77%. Seeds of *C. nitida* collected from protected area have the highest mean germination % of 59.33% while seeds of *C. nitida* collected from farm land had the lowest germination % of 39.33% (Table 3). Considering seeds collected from protected area, large seeds of *G. kola* gave the highest germination % of 67.00% while small seeds of *G. kola* gave the lowest germination % of 32.16%. Large seeds of *C. nitida* gave the highest germination % of 81.11% while small seeds of *C. nitida* gave the lowest germination % of 39.22%. Considering seeds collected from agroforestry plots, large seeds of *G. kola* gave the highest germination % of 62.58% while small seeds of *G. kola* gave the lowest germination % of 27.58%. Large seeds of *C. nitida* gave the highest germination % of 65.88% while small seeds gave the

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lowest germination % of 32.22%. Considering seeds collected from farm land, large seeds of *G. kola* gave the highest germination % of 43.75% while small seeds of *G. kola* gave the lowest germination % of 19.50%. Large seeds of *C. nitida* gave the highest germination % of 39.33% while small seeds gave the lowest germination % of 26.44% (Table 3).

Table 3: Mean Table for Effects of Land Use Types and Seed Sizes on the Germination Percentage of *G. kola* and *C. nitida* Seeds.

Land use Type	Seed Sizes	*G. kola*	*C. nitida*
		Mean±SD	Mean±SD
Protected Area	Small	32.16±13.10c	39.22±19.74c
	Medium	55.83±18.10b	57.66±16.16b
	Large	67.00±19.91a	81.11±10.61a
	Total	51.66±22.32	59.33±23.24
Agroforestry Plots	Small	27.58±11.08c	32.22±16.20c
	Medium	54.83±17.83b	50.22±14.24b
	Large	62.58±17.81a	65.88±6.47a
	Total	48.33±21.68	49.44±18.77
Farm land	Small	19.50±8.21c	26.44±12.92c
	Medium	35.08±8.74b	40.55±13.75b
	Large	43.75±10.85a	51.00±13.05a
	Total	32.77±13.63	39.33±16.34

Mean ± SD with the same alphabet in the column are not significantly different (p≤0.05)

Table 4: ANOVA Table for Influence of Land Use Types and Seed Sizes on germination percentage of *G. kola* and *C. nitida* in Nigeria.

Source of Variation	*G. kola*		*C. nitida*	
	df	Sig.	Df	Sig.
Location	2	0.00*	2	0.00*
Seed sizes	2	0.00*	2	0.00*
L * S	4	0.58ns	4	0.45ns
Error	99		72	
Total	107		80	

*- significant (p<0.05); ns-not significant (>0.05)

Result of ANOVA revealed that land use types significantly affect the germination % of both *G.kola* and *C. nitida* seeds (Table 4), seed sizes significantly affected the germination % of both species while there was no interaction effect of land use types and seed sizes on the germination % of *G. kola* and *C. nitida* respectively (Table 4). Mean separation result showed that the germination % of large seeds of *G. kola* collected from protected area, agroforestry plots and farm land were not significantly different from each other, germination % of medium seeds of *G. kola* seeds collected from protected area, agroforestry plot and farm land were not also significantly different from each other while germination % of small seeds of *G. kola* collected from protected area, agroforestry plot and farm land were not significantly different from each other (Table 3) while that of *C. nitida* followed same trend (Table 3).

Correlation between seeds sources, seed sizes, germination and early growth performance of *C. nitida* and *G. kola* in Nigeria

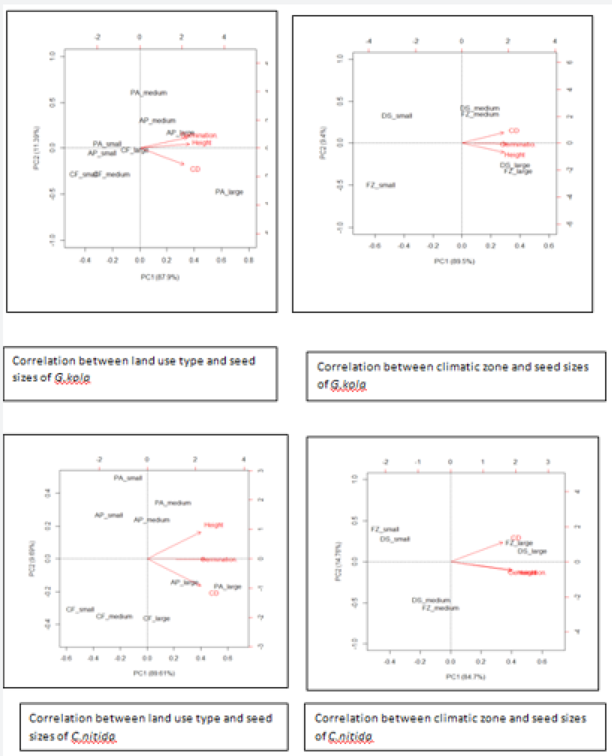

Figure 2: Principle component analysis showing the response of seed sources to germination and early growth performance of *C. nitida* and *G. kola*.

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To appreciate the relation between seeds sources, seed sizes, germination and early growth performance of *C. nitida* and *G. kola* in Nigeria, principal component analysis was used with the R software. The first component explains 89.61% and 87.9% of the information's about the correlation between climatic gradient and early growth of *C. nitida* and *G. kola* in Nigeria; which is sufficient to guarantee the precision of interpretation (Figure 2).

The results shows that germination percentage and growth variables assessed (Height and Collar diameter) are positively correlated with large seeds which implies that increase in seed sizes of *C. nitida* and *G. kola* seeds will lead to increase in germination percentage and growth, while smaller seeds are negatively correlated with growth variables which imply that decrease in any seeds will lead to decrease germination percentage and growth *C. nitida* and *G. kola*. seeds from protected area and agroforestry plots looks more appropriate because is positively correlated with the germination percentage and early growth unlike seeds from compound farm that are negatively correlated with germination percentage and growth assessed.

Discussion

The two species studied here showed similar germination patterns in the two-germination study. In both study the final germination percentage and early growth was significantly influenced by seed sizes. Many studies have shown that seed size very often have significant influence on germination percentage and germination rate, and even on resistance to intra or interspecific competition. Harper [14], reported that the poorer performance of lighter seeds is due to their lower endosperm content. Our results are going in the same direction with this hypothesis, in both species heavier seeds showed significantly greater germination percentage. The findings revealed that the different seed sizes significantly affect the germination potential of *G. kola* and *C. nitida* respectively. The findings are also in agreement as reported by Yulan et al. [15], who reported that seed germination and early seedling growth of Pinus yunnanensis was strongly related to seed size and seed weight. Bigger seeds germinated earlier and faster than small seeds. Large seeds of *G. kola* and *C. nitida* gave the highest germination percentage compared with the small and medium seeds and there seedling was positively correlated with seed size.

Results revealed that climatic gradient does not significantly affects the germination percentage of *G. kola* and *C. nitida* in Nigeria which implies that climatic gradient of the two seed sources (rain forest area and derived savannah) did not exert any effect on the germination potential of the seeds of *G. kola* and *C. nitida*. This is in contrast to the findings of Gallagher et al. [16], who reported that seed provenance significantly affected germination of *Andropogon gerardi*, *Sorghastrum nutans* and *Bouteloua curtipendula* seeds. Land use types affected the germination potential of both *G. kola* and *C. nitida* this could be as result of anthropogenic activities and silvicultural practices in the different locations. The results are in agreement with the work that was earlier reported for *Adansonia digitata* [17], *Pinus wallichiana* [18], and *Combretum aculeatum* [19]. The findings are in agreement as reported by Ekta et al. [20], that large seeds exhibited greater biomass and other growth traits compared with smaller seeds. According to Milberg & Lamont [21], seedlings from large seeds have a better start in life due to greater amount of carbohydrates in their endosperm or cotyledons than small seeds. This could enable early development of an enlarged resource-gathering system (root or photosynthetic tissue) to produce faster-growing plants [22].

It has been suggested earlier that variability in the responses of seeds of different populations to germination treatments may be due to environmental differences between the populations as reported by [23-26]. When examination of the interactions between seeds from different land use type, the results showed that that land use types significantly affected the germination percentage of both *G. kola* and *C. nitida* seeds, seeds from protected area with little or no human disturbance had the highest germination percentage while the seeds from compound farms had the least germination, these could be as a result of anthropogenic activities in the area.

Conclusion

This study was design towards getting insight on the propagation of indigenous fruit tree, which could possibly be incorporated to agroforestry system. The study aimed to ascertain the influence of climate, land use type and seed sizes in germination percentage of *G. kola* and *C. nitida* in Nigeria. The results obtained shows that the two studied species responded same way to seed sources and seed morphological characters (seed sizes) in germination percentage. These studies have provides the information on the appropriate seeds sources and adequate seed sizes to be sown to ensure and attain desired germination percentage.

It is quite easier to conserve the existing populations than to restore them once they are lost. The survival of the remaining populations of these highly economics species (*G. kola* and *C. nitida*) dependent on the commitment of the relevant local communities and national institution.

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