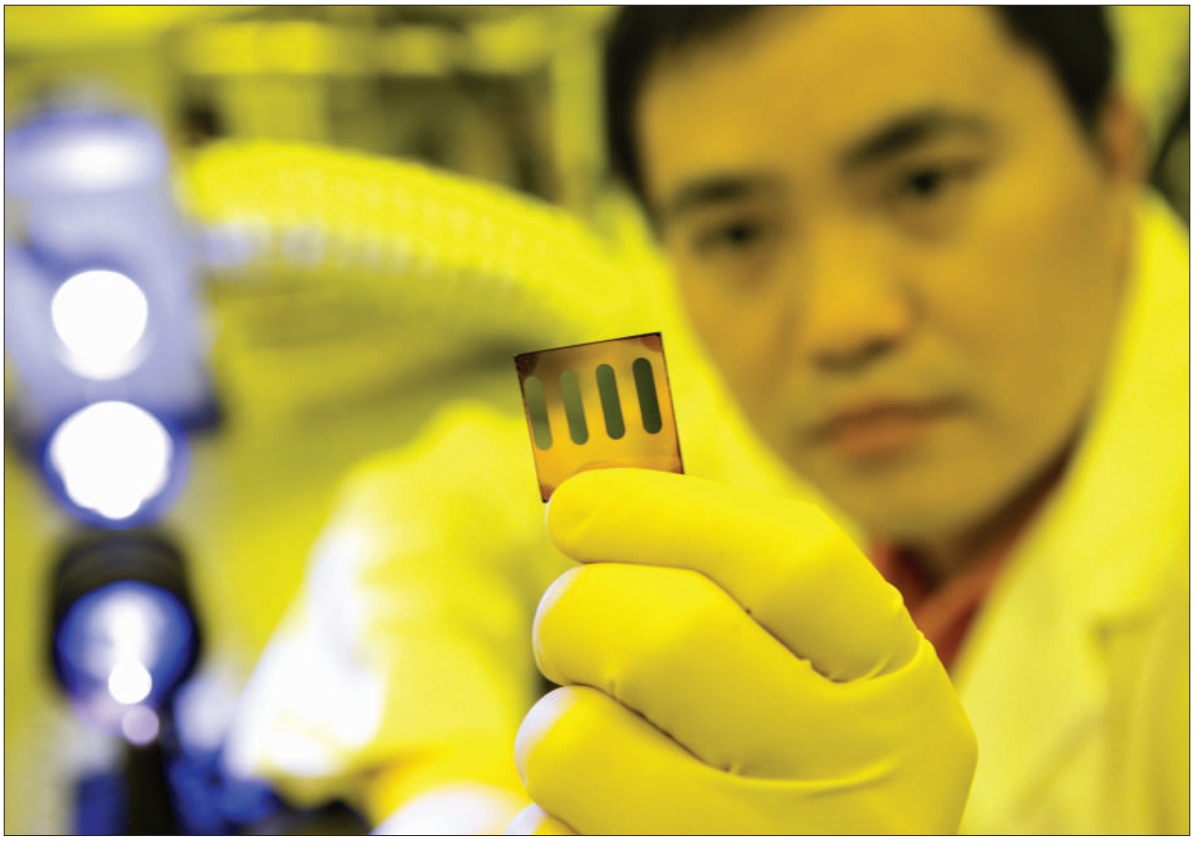

Singapore Journal of

Scientific Research

ISSN: 2010-006x

science alert

http://scialert.net/sjsr

OPEN ACCESS Singapore Journal of Scientific Research

ISSN 2010-006x
DOI: 10.3923/sjsres.2021.10.16

Research Article
Scion Source Effects on the Growth Performance of Grafted Seedlings of *Garcinia kola* Heckel

[1]F.B. Yakubu and [2]A. O. Akinyele

[1]Multipurpose Tree Species Improvement and Multiplication Unit, Forestry Research Institute of Nigeria (FRIN), P.M.B. 5054, Jericho Hill, Ibadan, Nigeria
[2]Department of Forest Production and Products, Faculty of Renewable Natural Resources, University of Ibadan, Ibadan, Nigeria

Abstract

Background and objective: Most Indigenous Fruit Tree species (IFTs) in the wild are difficult to propagate vegetatively due to physiological incompatibility, among other factors. This could be overcome by using grafting techniques with appropriate selected Mother Trees (MTs) and scion sources. This study was designed to investigate the effects of scion source and mother trees on the early growth performance of grafted seedlings of *G. kola*. **Materials and Methods:** Mature seeds of *G. kola* were collected from Edo State Forest Reserve. The modified Cleft Grafting method was used to graft *G. kola* with scions from five MTs randomly selected from each of the locations. Total graft survival (%), graft survival per MT (%), plant height (cm), collar diameter (mm) and number of leaves were measured at 14 days interval for six months. Data were analyzed using descriptive statistics and analysis of variance (ANOVA) at 0.05. **Results:** Seedlings of *G. kola* grafted with scions collected from Gambari Forest Reserve (GFR) had higher survival with 52%. This can be attributed to the distance of scion collection to the experimental site. The highest survival per MT of *G. kola* were14.0 and 12.0% in GFR and OLFR respectively and the least per MT of *G. kola* were 0 and 4% in OLFR and OFR respectively. OLFR had the highest plant height and number of leaves of grafted *G. kola* seedlings followed by GFR and OFR. OFR had the widest Collar diameter of grafted *G. kola* seedlings followed by GFR and OLFR. **Conclusion:** Scion from Gambari Forest Reserve showed high compatibility with the root stock from different sources. Optimum graft survival and growth performance was obtained in *Garcinia kola*.

Key words: Fruit trees domestication, modified cleft grafting, *Garcinia kola*

Citation: Yakubu F.B. and A.O. Akinyele, 2021. Scion source effects on the growth performance of grafted seedlings of *Garcinia kola* heckel. Singapore J. Sci. Res., 11: 10-16.

Corresponding Author: F.B. Yakubu, Multipurpose Tree Species Improvement and Multiplication Unit, Forestry Research Institute of Nigeria (FRIN), P.M.B. 5054, Jericho Hill, Ibadan, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Forest trees improvement programs have traditionally been timber-oriented and it is only in the last few years that high-valued agroforestry trees, especially those for fruits/nuts production, have been the subject of domestication and improvement of yield and quality[1]. There are new initiatives in tropical forest tree improvement aimed at developing cultivars of trees with desired fruits, nuts and medicinal characteristics[1].

Among the Multipurpose Tress species (MPTs), *Garcinia kola* belongs to the basic Indigenous Fruit Tree species (IFTs) that are of economic importance, and are currently vulnerable to extinction problems[2]. Because of this multiple uses ranging from cumber, medicinal uses of all its parts.

Matured parental traits are not preserved through seed propagation because of cross-pollination and fertilization. Thus vegetative propagation does not have the issue of segregation because it is a mitotic process. It is known that vegetatively propagated plants primarily depend upon location of tree and proper grafting method to be successful[3]. Vegetative propagation techniques are the most effective method to produce planting stocks for the production of true to type plants[4]. Success of the grafting method varies from species to species. Grafted IFTs like *Irvingia wombolu* bear fruits in 5 - 6 years while the ungraded trees will take 20 - 25 years[5].

The root stock and scion incompatibility has restricted grafting for commercial propagation of IFTs because of poor success. This could be as a result of cambiums not matching properly for contact or scions are upside down, grafting done at the wrong time, rootstock or scion are not healthy and the graft is not properly covered with grafting wax. At times, it may be due to attacked by insects or disease or the graft union is girdled because the tape was not cut or released in time[6].

Harvesting of indigenous tree species in forms of timber and fruit gathering depended largely on natural population of the existing trees from the forest without conscious effort at replacing through plantation establishment. It is found almost impossible to establish the plantation of some indigenous trees species owing to difficulties in collection and storage of viable seeds resulting in germination problems. The starting point of fruiting for some of these indigenous trees and fruits trees ranges from 12 - 15 years and sometimes 30 years. However vegetative propagation is able to overcome the difficulties of delayed fruiting time because matured materials of good desirable qualities are selected through grafting, budding, cutting and air layering. Past research efforts on grafting trials for IFTs were reported to be faced with various shortcomings such as grafting success, technical ability of the scientist, periods in the year the scion is collected and the time interval between scion collection and grafting[7,8]. Grafting may be limited by phenolic accumulation at the graft union line leading to the possibility of failure[9].

The current importation of fruits into the country shows the needs for constant production to meet the local needs to avoid shortfall in supply. Planting activities are often constrained by the lack of superior sources of planting stock[1]. Generally, approaches have adopted vegetative propagation and the development of cultivars by identifying suitable materials[10]. The increased interest in vegetative propagation has risen from the desire to rapidly acquire higher yields, early fruiting and better quality fruit products in fruit tree species[11]. IFTs grafting have addressed intricate problems and enhanced the collection of desirable fruit traits[7]. Vegetative propagation is a means of capturing and utilizing genetic variation to produce cultivar that can increase productivity and quality. This results in the formation of cultivars which retain the genetic traits of the original tree where scions were collected[12]. The need to quickly determine a large genetic variability in the wild tree species require vegetative propagation, plant tissues that are physiologically matured can be captured through vegetative propagation[13-15]. This research therefore was carried out to make available seedlings of good traits and reduction of gestation period.

MATERIALS AND METHODS

The scions of *Garcinia kola* were collected from three different States namely; Oyo (Gambari Forest Reserve), Ogun (Omo Forest Reserve), Ondo (Oluwa Forest Reserve). The research was carried out on the grafting of scions on the rootstocks of *G. kola*. Survival of grafts of the species from three locations was investigated.

This research was conducted in 2017 and it was aimed at the propagation of *G. kola* through grafting with a view to raise fast regenerating and early-fruiting planting stocks.

Therefore, the effect of scion source on the survival of grafted seedlings of *G. kola,* the assessment of the effect of scion source on the early growth development of grafted seedlings of *G. kola;* and the effect of scions collected from different mother trees on the survival and early growth and development of grafted seedlings of *G. kola* were studied.

This study was carried out at the West African Hardwood Improvement Project (WAHIP) nursery in Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State. FRIN is located on the longitude 07°23'18''N to 07°23'43''N and latitude

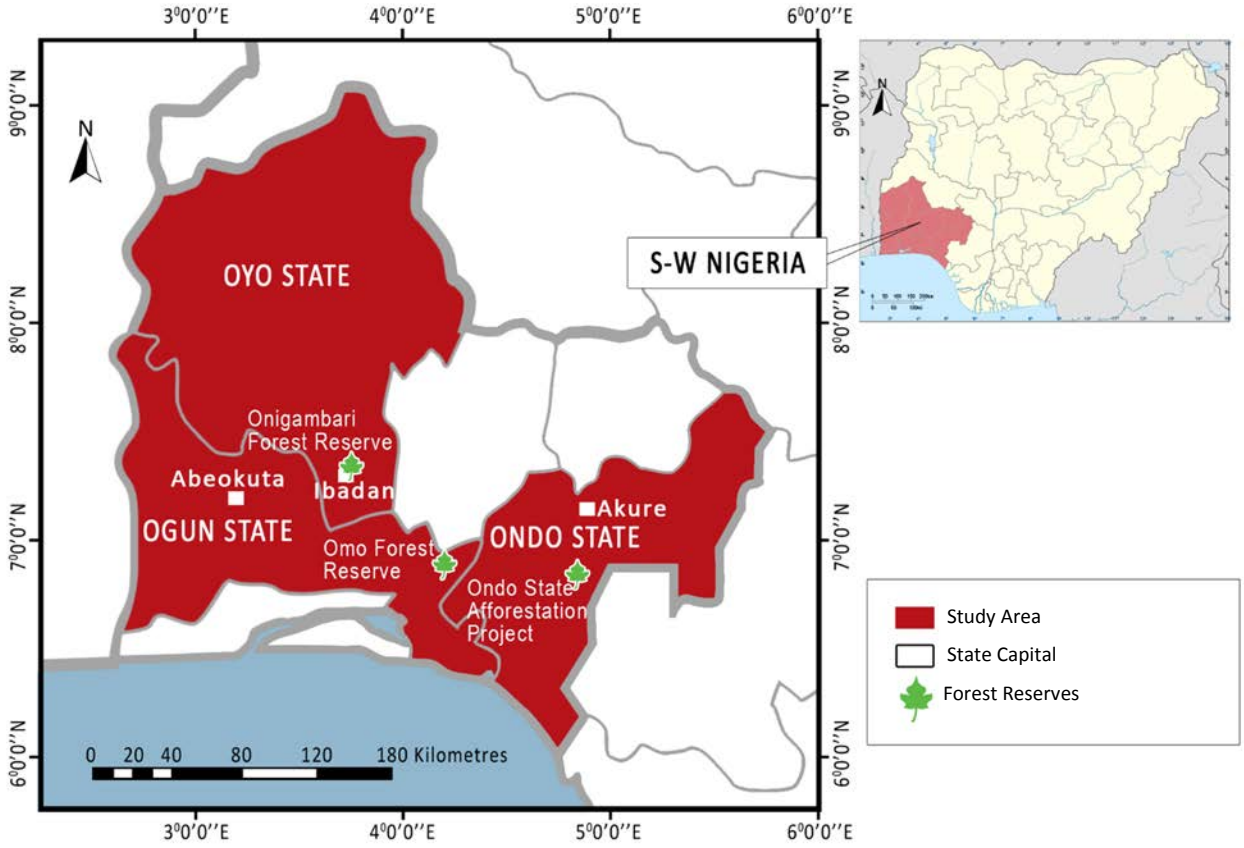

Fig. 1: Map of South Western Nigeria showing the Study Areas
Source: Field work 2017

03°51'20''E to 03°51'43''E as shown in Fig. 1. 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 1548.9 mm, 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%[16].

The scion for the tree species (*Garcinia kola)* were collected from three different States namely; Oyo (Gambari Forest Reserve), Ogun (Omo Forest Reserve), Ondo (Oluwa Forest Reserve). Ten (10) scions were collected from each of the mother trees (MT).

The seeds for the root stock of *G. kola* were collected in Ehor Forest Reserve, Edo State. A total of 150 seedlings of *G. kola* were raised for one year at the Fruit Trees Nursery, Sustainable Forest Management Unit, FRIN and prepared for grafting.

The experimental design is Completely Randomized Design (CRD). The experiment comprised of three treatments (location) namely; Oyo (Gambari Forest Reserve), Ogun (Omo Forest Reserve) and Ondo (Oluwa Forest reserve). Each treatment is replicated fifty (50) times.

Statistical design for CRD: The statistical model is

$$Y_{i,j,} = \mu + Ti + e_{i,j} \quad (1)$$

Where:

$Y_{i,j}$ = Individual observation
μ = Overall mean
T_i = Effect of scion location
e_{ij} = Experimental error

Fifty scions were collected from each location Oyo (Gambari Forest Reserve), Ogun (Omo Forest Reserve) and Ondo (Oluwa Forest reserve), making a total of one

hundred and fifty scions. The scions were collected from the matured trees of *G. kola.* The method used for the grafting experiment was Modified Cleft Grafting (MCG) according to Yakubu *et al.*[5].

Grafting procedure: The scions were identified and collected from the selected mother tree. The selection of the scions was based on good taste, big fruit and low seed content. One year old (green bud-120mm diameter) scions were selected from branches at an area that was close to the center of the canopy using ladder. Wet jute material was used to wrap the collected scion and placed inside transparent polythene sheet to avoid desiccation during transportation to the nursery site for grafting.

A clean slant cut was made from the bark of the rootstock to the pith using a very sharp sterilized budding knife (Plate 1). The slits cut (tongues) from the scion about 2.5-3.5 cm deep was matched unto the surface of each cut of the rootstock. The graft was made by gently pushing the scion into the rootstock and interlocking the tongues (Plate 2). This was wrapped with a budding tape, winding from the bottom up, and slipping the end under the final loop. The prepared stocks were placed under mist propagator chamber for 4 weeks. Once the scion and stock remain green after 4 weeks, the stock from the point of union was cut off to allow the scion and the root stock to develop. The grafted plant stocks were left inside the mist propagator chamber for another 4 weeks to stabilize before removing to weaning shed. Watering was carefully done from the base to avoid water entering the point of union and subsequent decay of grafts.

Data were collected on the survival percentage (success rate) of the grafted seedlings of *G. kola* after 4 weeks.

Ten uniformly survived grafted seedlings were selected and monitored for growth characteristics for five months. Watering was done daily. Data were collected on the development of the grafted seedlings by measuring the following: height (cm) with a ruler, collar diameter (mm) with a digital caliper and visual count for number of leaves for a period of 6 months.

Data analysis: Data collected on survival of the grafted seedlings were subjected to descriptive analysis while analysis of variance (ANOVA) was used to compare the effects of the scion collected from the different locations on the early development of grafted *G. kola*. Significant means were separated using least significant difference (LSD).

Plate 1: Grafted *G. kola* seedlings under mist propagator chamber

Plate 2: Flowering of *G. kola* seedlings five months after successful grafting

RESULTS

The result revealed that *G. kola* scion collected in Gambari Forest Reserve performed best compared to the other scions collected from Omo Forest Reserve and Oluwa Forest reserve. Seedlings of *G. kola* grafted with scions collected from Gambari Forest Reserve had the highest survival rate of 52%, followed by scions collected from Omo Forest Reserve which had 46% survival rate while scions collected from Oluwa Forest reserve had the least survival rate of 26% (Fig. 2; Plate 1).

The mean grafted scion height ranged from 59.40 to 63.03 cm with the highest mean height from grafted seedlings from

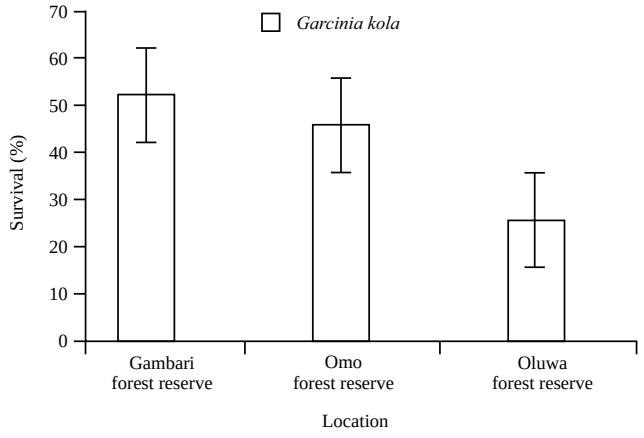

Fig. 2: Survival percentage of grafted Seedlings of *G. kola* from three locations

Table 1: Mean height, collar diameter and number of leaves of grafted *G. kola* seedlings

Location	Height (cm)	Collar Diameter (mm)	Number of Leaves
Gambari Forest Reserve	60.35±2.83^{ns}	12.63±0.63^{ns}	33±3.99*
Omo Forest Reserve	59.40±4.28^{ns}	11.64±0.38*	21±11.38*
Oluwa Forest Reserve	63.03±2.86^{ns}	13.55±0.52*	46±12.09*
LSD Value	4.8	0.74	5.39

*Significant ($p \leq 0.05$), ^{ns} : not significant ($p > 0.05$)

Table 2: Analysis of variance result on the effect of scion sources on the height, collar diameter and number of leaves of grafted seedlings of *G. kola*

Parameter	SV	df	SS	MS	F	Significant
Height	Location	2	71.01	35.51	0.31	0.74^{ns}
	Error	27	3104.7	114.99		
	Total	29	3175.7			
Collar Diameter	Location	2	18.14	9.07	3.36	0.05*
	Error	27	72.99	2.7		
	Total	29	91.13			
Number of leaves	Location	2	2904.3	1452.2	10.01	0.00*
	Error	27	3918.7	145.14		
	Total	29	6823.1			

* Significant ($p \leq 0.05$) ^{ns} : not significant ($p > 0.05$). SV : Sources of variation, df : Degree of freedom, MS : Mean of square, SS : Sum of square

Table 3: Effects of Mother tree on mean survival % of *G. kola*

Mother trees	OLFR	OFR	GFR	Pooled mean
Mother tree 1	-	8	4	4
Mother tree 2	8	10	14	23
Mother tree 3	6	12	12	10
Mother tree 4	8	8	12	9
Mother tree 5	4	8	4	5

Ten scions were collected from each of the mother trees. OLFR : Oluwa forest reserve, OFR : Omo forest reserve, GFR : Gambari forest reserve

Ondo State (Table 1). However, ANOVA indicated that there were no significant differences ($p > 0.05$) in the height of grafted *G. kola* scions collected from the three locations when compared together (Table 2).

Collar diameter of grafted *G. kola* seedlings: There were significant differences ($p \leq 0.05$) in the collar diameter of scions grafted on *G. kola* seedlings (Table 2). The mean seedling diameter ranged from 11.64 to 13.55 mm with the highest mean observed for grafted seedlings from Oluwa forest reserve while the least collar diameter was observed from grafted seedlings from Omo forest reserve (Table 3). Mean separation revealed that the growth in collar diameter of scion grafted from Oyo state is not significantly different from the collar diameter of scions grafted from Omo forest reserve and Oluwa forest reserve (Table 3).

Leaf production of grafted *G. kola* seedlings: Analysis of variance indicated that there were significant differences ($p \leq 0.05$) in the leaves produced by scions grafted on *G. kola* seedlings (Table 2). The mean seedling leaf production ranged from 21 to 46 leaves with the highest mean observed for grafted seedlings from Oluwa forest reserve while the least leaf production was observed from grafted seedlings from Omo forest reserve (Table 1). Mean separation revealed that the leaves produced by grafted seedlings from the three locations were significantly different from each other, when compared (Table 1).

The result showed that mother tree source for scion collected in Gambari Forest Reserve performed best compared to the other mother trees sources in Omo Forest Reserve and Oluwa Forest Reserve. Scions of *G. kola* collected from mother tree 2 in Gambari Forest Reserve had the highest survival rate of 14% which was followed by scions of *G. kola* collected from mother trees 3 and 4 which had same survival rate of 12% each. Scions of *G. kola* collected from mother trees 1 and 5 which had same survival rate of 4% each. Scions of *G. kola* collected from mother tree 3 in Omo Forest reserve had the highest survival rate of 12%, followed by mother tree 2 with survival rate of 10%, while mother tree 1, 4, and 5 had same survival rate of 8% each. Lastly, scions of *G. kola* collected from mother trees 2 and 4 in Oluwa Forest Reserve had the highest survival rate of 8%, each, followed by scion collected from mother tree 3 which had survival rate of 6%, followed by mother tree 5 which had survival rate of 4%. Mother tree 1 had 0% survival rate (Table 3)

DISCUSSION

Grafting success of *G. kola* was high with the scions collected in Gambari Forest Reserve compared to the scions collected from Omo Forest Reserve and Oluwa Forest Reserve which was rather low. The grafting process took place in

Ibadan, Oyo State which implies that the scions collected in Gambari Forest Reserve were grafted almost immediately after collection.

This resulted to the higher survival percentage of scions collected from the Gambari Forest Reserve. The low survival rate of scions collected from the Omo Forest Reserve and Oluwa Forest Reserve can be attributed to the distance of scion collection which took a longer time to arrive the experimental site. Location to the grafting site and the latex produced by *Garcinia kola* might cause a reduction in the survival percentage if the scions are not grafted quickly. *G. kola* is found to have latex cells and vessels and upon cut, produce milky juice which tends to make grafting and budding difficult to heal and establish.

The result of this study shows that scion sources affected the survival percentage of scion after grafting. This is in correlation with the work of Munjunga *et al.*[17] who reported that scion sources affected the survival percentage of scions grafted on *Allanblackia stuhlmannii* seedlings. The results indicated that *G. kola* can be successfully grafted using the modified cleft method. This has been previously demonstrated by Yakubu *et al.*[5,18]. In many species, it has been reported that cleft grafting is easier to use and more successful than other methods of grafting[19,20,21]. However, in other species moderate temperature and high relative humidity are major factors related to the success of grafts[22].

The increase in the height of scion grafted on *G. kola* seedlings supports the work of Yakubu *et al.*[18] who reported increase in height of grafted *G. kola* seedlings using the modified cleft method. The result from this study showed no significant difference in the height of shoots produced from scion grafted on *G. kola* seedlings. The result from this study on the shoot height of *G. kola* is in correlation with the research work of Anjarwalla *et al.*[23].

The increase in the collar diameter and leaf production of scion grafted on *G. kola* seedlings supports the work of Yakubu *et al.*[18] who reported increase in collar diameter and leaf production of grafted *G. kola* seedlings using modified cleft method. The result from this study also showed a significant difference in the collar diameter and leaf production of scions from different locations grafted on *G. kola* seedlings. The significant differences in the collar diameter and leaf production of scions from the different locations grafted on *G. kola* seedlings might be due to some genetic differences between the individual trees as similarly shown for *Cola nitida* by Dadzle *et al.*[24]. So far, there is little or no information with regard to the performance of scions collected from different locations on *G. kola* and other economic fruit tree species in Nigeria from the literature. Thus, this work provides basic and advanced information on grafting of indigenous fruit trees, an important aspect of indigenous fruit trees improvement in Nigeria.

CONCLUSION

Scion collection location to grafting site affected the percentage survival of grafts of *G. kola*. Scion collection location should not be far from the grafting site. The problems associated with these species are the production of copious exudates/latex which occurs when cuts are made during grafting. This hinders callus formation and equally helps the development of fungi which reduces the survival rate of grafted seedlings. However, successful domestication and cultivation of *G. kola* through grafted seedlings will enhance the conservation of these species.

SIGNIFICANCE STATEMENT

This study discovers the possibility of successful grafting *Garcinia kola* with the aim of reducing the gestation period and making it available to farmers. This will lead to an increase and quick economic returns instead of waiting for a long gestation period.

The farmer can easily be taught this low level of technological input of grafting than those obtainable in all forms of Biotechnology, thus leading to poverty alleviation.

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