

**POTTING MEDIA AND SEED PRE-SOWING TREATMENTS INFLUENCING  
EMERGENCE AND EARLY SEEDLING GROWTH OF BITTER KOLA  
(*GARCINIA KOLA* HECKEL) UNDER HUMIDITY CHAMBER ENVIRONMENT**

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## ABSTRACT

Despite the enormous socioeconomic and therapeutic potentials of bitter *kola* (*Garcinia kola* Heckel), organized cultivation of the species is still very rare, owing to the scarcity of the seedlings predicated on seed dormancy challenges. This study aims to develop a workable protocol for seed germination of bitter *kola* using four growth media [including rice husk (RH), sawdust (SD), river sand (RS) and a soilless medium RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> formulated in volume ratios of RH, poultry manure (PM), and SD]; and five seed pre-sowing treatments [decortication by coat removal, soaking seeds in water for 24 h, 48 h, or 72 h; plus the untreated control seeds]. Seedling emergence and early growth of bitter *kola* were studied across the treatments in factorial combinations under a humidity growth chamber in a completely randomized design (CRD) replicated in three plastic baskets containing 10 seeds each. Results showed that seedling emergence was significantly ( $p < 0.05$ ) earliest in RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> (69 days) and RS (74 days), followed by SD (81 days), and the latest in RH (104 days). Percentage emergence was high and statistically similar in RS (95.3%), SD (90.0%), and RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> (86.8%) but significantly ( $p < 0.05$ ) poor in the RH (55.9%) medium. The earliest seedling emergence was recorded in 49 days with the decorticated seeds sown in RS medium. Decorticated seeds with the 48 h and 72 h presoaked seeds recorded 100% emergence in RS. The decorticated seeds also had 100% emergence in SD and RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub>. Seeds presoaked for 48 or 72 h and raised in RS produced the tallest seedlings. Across the seed treatments, seed decortication and the 48 and 72-h soaking durations significantly ( $p \leq 0.05$ ) produced seedlings with the highest number of leaves. Similarly, RS, SD and the soilless medium RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> produced seedlings with a greater number of leaves compared to the RH medium. For prompt germination of bitter *kola* seeds with vigorous seedling growth, seed decortication or soaking for 48–72 h are the recommended pre-sowing treatments. Regarding the potting media, river sand gave the best results (in terms of emergence and early seedling growth); however, sawdust and the soilless nursery mix (RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub>) are equally good for raising bitter *kola* seedlings under a warm humidity growth chamber. The use of high humidity growth chamber– a miniature greenhouse is a simple technology which can easily be adopted by local and peri urban farmers in commercial propagation of bitter kola.

**Key words:** *Garcinia kola*, seed treatments, juvenile growth, controlled environment



## INTRODUCTION

Bitter *kola* (*Garcinia kola* Heckel), also known as African wonder nut, is a species of flowering plant that belongs to the family Guttiferae (also termed Clusiaceae)– a group of tropical trees and shrubs characterized by milky sap and fruits comprising 13 genera and about 750 species [1]. Bitter *kola* is chiefly found in the rainforest belt of West and Central Africa, extending from Sierra Leone to the Democratic Republic of Congo [2]. *Garcinia kola* has been referred to as a ‘wonder plant’ since every part of it has some medicinal importance [3]. In addition, it is called bitter *kola* because of the characteristic bitter taste [3] and ‘male kola’ due to the reported aphrodisiac properties [4]. In Nigeria, it is commonly called ‘Orogbo’ in Yoruba, ‘Aku ilu’ in Igbo and ‘Namijin goro’ in Hausa [3].



**Plate 1: Decorticated (milk-colored) and undecorticated (brown-skinned) bitter *kola* seeds**

Bitter *kola* is highly valued for its medicinal, nutritional and socioeconomic benefits [5]. Traditionally, the seeds (shown in Plate 1) are chewed as a masticatory substance to stimulate the flow of saliva [3] and are widely traded at a premium price in both local and international markets. They are eaten as a stimulant [6] and, in some cultures, serve as cola to visitors and in ceremonies. In addition, they are chewed for aphrodisiac effects [4] and used to cure cough, dysentery and chest cold [3]. Due to their therapeutic properties, the fruits, seeds, leaves, roots and bark of bitter *kola* have been used for centuries to treat ailments from coughs, fever, throat infection, bronchitis, hepatitis and liver disorder [4, 7]. Furthermore, the chopped sticks are traded as chewing sticks for oral hygiene [6]. Bitter *kola* contains vitamins, minerals, proteins and carbohydrates in varying quantities and phytochemicals, such as alkaloids, flavonoids, tannins, cyanogenic glycosides, and saponins, among others which gave its characteristic dietary, therapeutic and ethnomedicinal properties [5, 8].

*Garcinia kola* grows in the humid rainforests near the coast and can tolerate shade but grows faster in the open. It grows as a medium-sized tree reaching about 14 m high, although characterized by a slow growth rate [2]. The fruits are normally picked from July to October. The fruits are reddish-yellow when ripe and approximately 6.25cm in diameter, and each fruit contains two to four brown seeds embedded in an orange-colored sour-tasting pulp [2]. When planted from seed, the tree can bear fruits in 10 to 12 years.

The fresh, mature seeds are highly dormant but viable, creating difficulties with rapid and uniform germination [9]. Germination of intact fresh seeds is about 50%, starting after approximately 3 months at ambient temperatures (25–28 °C); however, most seeds would germinate in 7–8 months after sowing and, at times, would continue to germinate even after 18 months.

Notwithstanding the enormous socioeconomic and therapeutic potentials of bitter kola, organized cultivation of the species is still very rare, owing to the scarcity of the seedlings predicated on the seed dormancy challenges. The species is largely being exploited from the wild for the edible fruits, seeds, roots, leaves and bark, which are widely used in ethnomedicine. Consequently, there is a need to develop simple and scalable techniques for regenerating the species for extensive planting to prevent possible extinction. Factors that discourage farmers from establishing *Garcinia kola* fields include the long juvenile growth and the shortage of seedlings blamed on difficulties associated with the seed germination [10] and seedling development. Most productive trees are wildlings left when farmers cleared forest plots [11], and a few that sprang around homesteads. Researchers have studied the germination problems of *G. kola* seeds and suggested means of breaking its dormancy with varying degrees of success, necessitating some further investigation [10, 12, 13, 14, 15, 16, 17]. Vegetative propagation provides the best option for solving the problem of seed dormancy in many recalcitrant species [18]; however, it would require specialized skill and training.

*Garcinia kola* seeds have both seed coat dormancy and physiological dormancy, probably imposed by the inherent phytochemicals in the seed [15, 19]. Seed coat dormancy of *G. kola* could be overcome by removing the seed coat before sowing. In contrast, physiological dormancy could be reduced by soaking the seeds in water before sowing [10].

This study aims to develop a workable protocol for germinating stored bitter *kola* seeds to plantable seedlings since the freshly harvested seeds are not readily





available for propagation most of the year. Therefore, the effects of four (4) growth media and five (5) seed pre-sowing treatments were studied under a humidity chamber (Plate 2) environment on the emergence and seedling growth of 4-month-old stored bitter *kola* seeds. A humidity growth chamber provides a consistently warm, humid, and translucent environment suitable for germinating most tropical recalcitrant species [20], and local farmers can easily adopt the technology.

## MATERIALS AND METHODS

### Experimental site

The experiment was conducted in a humidity chamber constructed at the Department of Crop Science Teaching and Research Farm, the University of Nigeria, Nsukka (07° 29' N, 06° 51' E, 400 m.a.s.l.), Enugu State, Nigeria. The humidity chamber consists of a mini-greenhouse with dimensions 2m × 5m × 1.5m, mounted on a block-wall base of height 0.6m, with a hinged door (measuring 0.5m × 1m) for accessibility (see pictures in Plates 2 and 3). The sides and roof were made of thick transparent polyethylene sheet (0.5mm thickness) to allow for light penetration, moisture conservation, and heat buildup within the chamber. In addition, the entire structure was provided with a translucent plastic roof to reduce direct insolation and avoid heat stress on the emerging seedlings. The experiment lasted 10 months, from 8th February to 8th December 2020. The mean morning and noon temperatures within the chamber during the study period were 28±1.9°C and 37±3.5°C, respectively, compared to the ambient mean temperature of 30.1°C earlier documented in the study area [21].



Plate 2: Humidity/Propagation chamber used for the study

### Experimental design and treatment application

The study is a 4 × 5 factorial experiment laid out in a completely randomized design (CRD). Factor A comprised four nursery potting substrates, including rice husk (RH), sawdust (SD), river sand and a soilless nursery medium RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> formulated from rice husk, poultry manure (PM), and sawdust mixed in volume ratios of 3:2:1, respectively. Factor B consisted of five seed pre-sowing treatments: thus (i) decortication by removal of entire seed coat, (ii) soaking seeds in water for 24 h, (iii) soaking seeds for 48 h; (iv) soaking seeds for 72 h and (v) the untreated control seeds. The factorial combinations (media × seed treatments) were replicated three times in three plastic baskets containing 10 seeds each, totaling 600 seeds. The potting baskets were filled to a three-quarter volume with the corresponding substrates during planting. The soaking water used for the seed treatments was renewed daily (until the desired duration was reached) to avoid microbial contamination of the seeds. Uniform watering of the seed baskets was conducted at weekly intervals. The entire floor inside the growth chamber was lined with moist sawdust to about 10cm thickness (before placing the seed baskets) to help conserve moisture and further humidify the environment.

### Seed collection

The bitter *kola* seeds used for the experiment were sourced from a tree at a farmer's residence in Umachi (07° 46' N, 06° 92' E) Enugu-Ezike, Enugu State, Nigeria. The seed lot was collected from fully ripe fruits, which were picked, extracted, washed and air-dried at room temperature for one week and stored in a plastic container covered with jute for four months before use.

### Data collection and analysis

Data were collected on days from 1<sup>st</sup> to the last seedling emergence. Seedling emergence was recorded on the first visible protrusion of the plumule to the surface of the nursery substrate. Seedling emergence was recorded daily for 8 months, during which emergence count (seedling emergence percentage per basket) was taken. Emergence span was recorded as the time spread of seedling emergence, the time in days between the first and last seedling emergence occurring in a seed lot [22]. Data were also taken on seedling height (cm), and the number of foliage leaves per seedling at 6, 8 and 10 months after planting (MAP). The data generated were subjected to analysis of variance following the procedures outlined for two-factor experiments in CRD using GenStat statistical software, Release 10.3 DE [23]. Treatment means were separated for the main and interaction effects, using Fisher's least significant difference (F-LSD) at a 5% probability level. The inter-relationship among the interacting factors (media × seed treatments) and the seedling emergence/growth parameters was further expressed



in a visual display chart using the 'Which-wins-where' or 'Which-is-best-for-what' model of the GGE-biplot analysis software [24].

## RESULTS AND DISCUSSION

Nursery media significantly ( $p \leq 0.05$ ) influenced most of the seedling emergence parameters of bitter *kola* (*Garcinia kola* Heckel) studied in Table 1. Seedling emergence was earliest in the formulated medium RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> (69 days) and river sand (74 days), followed by sawdust (81 days) but was delayed in the rice husk medium (104 days). The observed trend was consistent from the 1<sup>st</sup> seedling emergence to 50% emergence. Several studies have used these substrates singly and in combinations as nursery potting media, particularly for aeration, to promote gaseous exchange within the growth medium [20, 25, 26]. However, the rice husk medium used in the present study formed a surface crust that perhaps had obstructed gaseous exchange (within and around the seeds), limiting respiration, thereby negatively affecting germination, emergence, and seedling growth.

The porous nature of river sand and the sawdust medium must have enhanced airflow and gaseous exchange within and around the seeds to promote cellular respiration for prompt growth and development of the seed embryos. Therefore, the percentage of seedling emergence (that is, the proportion of the emerged seeds to the total number of seeds sown) was high and statistically similar in river sand (95.3%), sawdust (90.0%) and the medium RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> (86.8%); however, poor in the rice husk with a total emergence of 55.9%.

All the seedling emergence parameters were significantly ( $p \leq 0.05$ ) influenced by seed pre-sowing treatments (Table 1). Seedling emergence was earliest (64.6 days) in the decorticated seeds, followed by the 72 h presoaked seeds, whose 1<sup>st</sup> emergence occurred in 70.6 days, and then, the seeds soaked for 48 h, which emerged in 75.3 days. The 24 h soaking duration and the untreated control seeds recorded their 1<sup>st</sup> emergence in 101.9 and 100.3 days, respectively. There were no significant differences among the decorticated seeds, and those seeds which were soaked for 48 h and 72 h before sowing, in the number of days to 1<sup>st</sup> seedling emergence up to 50% emergence.

These results suggest that seed dormancy in *G. kola* could be overcome by seed pre-sowing treatments, particularly seed coat removal (decortication) or presoaking in water for 48–72 h, which confirms an earlier report that decoating (seed coat removal) enhances germination of *G. kola* seeds [15]. The authors noted that



soaking *G. kola* seeds in water for 24 h before sowing gave poor germination and growth responses, which were attributed to the short duration of soaking.

Similarly, the final percentage emergence was highest and statistically alike in the decorticated seeds (90.0%), and the seeds presoaked for 72 h (87.5%) and 48 h (84.9%). Seedling emergence percentage was comparatively low in the 24 h soaked seeds (78.8%) and the untreated control seeds (68.8%). The shortest emergence span of 61.8 days was recorded in the decorticated seeds, while the 24 h soaked and the untreated control seeds had the longest emergence span of 102 days and 104.5 days, respectively.

It is evident from this study that 24-h soaking duration would not be sufficient to fully solubilize and leach out the endogenous phenolic compounds reported to exert dormancy in *G. kola* seeds [19]. However, it was reported that the removal of the seed coat combined with 24-h soaking in water was effective in enhancing the germination of *G. kola* seeds [27], suggesting that part of the dormancy mechanism in *G. kola* seed is coat imposed.

In a more recent study, Yakubu *et al.* [10] reported that decoated seeds of *G. kola* soaked in water for 72 h and incubated in thick transparent polythene bags gave prompt germination within 12 to 62 days owing to light penetration, moisture availability and probably heat buildup. There are indications from this study that a soaking duration of 48 or 72 h was adequate for moisture imbibition to solubilize the inhibitory substances in the seeds, activate enzymes that hydrolyze (digest) the stored food in the endosperm, release energy and stimulate the growth of the embryos for prompt seedling emergence and development. Low seed moisture content seems to negatively affect the germination of *G. kola* seeds [19], hence the need for presoaking treatment and continuous moist incubation.

Significant ( $p \leq 0.05$ ) interaction effects of nursery media and seed pre-sowing treatments were recorded in most of the seedling emergence parameters studied in Table 2, confirming the need for choicest growth medium and seed pre-sowing treatment in the germination of *G. kola*. The earliest days of seedling emergence were recorded in the decorticated seeds sown in river sand. Days to 1<sup>st</sup> seedling emergence ranged from 49.3 days in the decorticated seeds raised in river sand to 156.5 days in the 24 h presoaked seeds raised in rice husk medium. Similarly, days to 50% emergence ranged from 67.0 days in the decorticated seeds raised in river sand to 217.0 days recorded in the 24 h soaked seeds raised in rice husk.





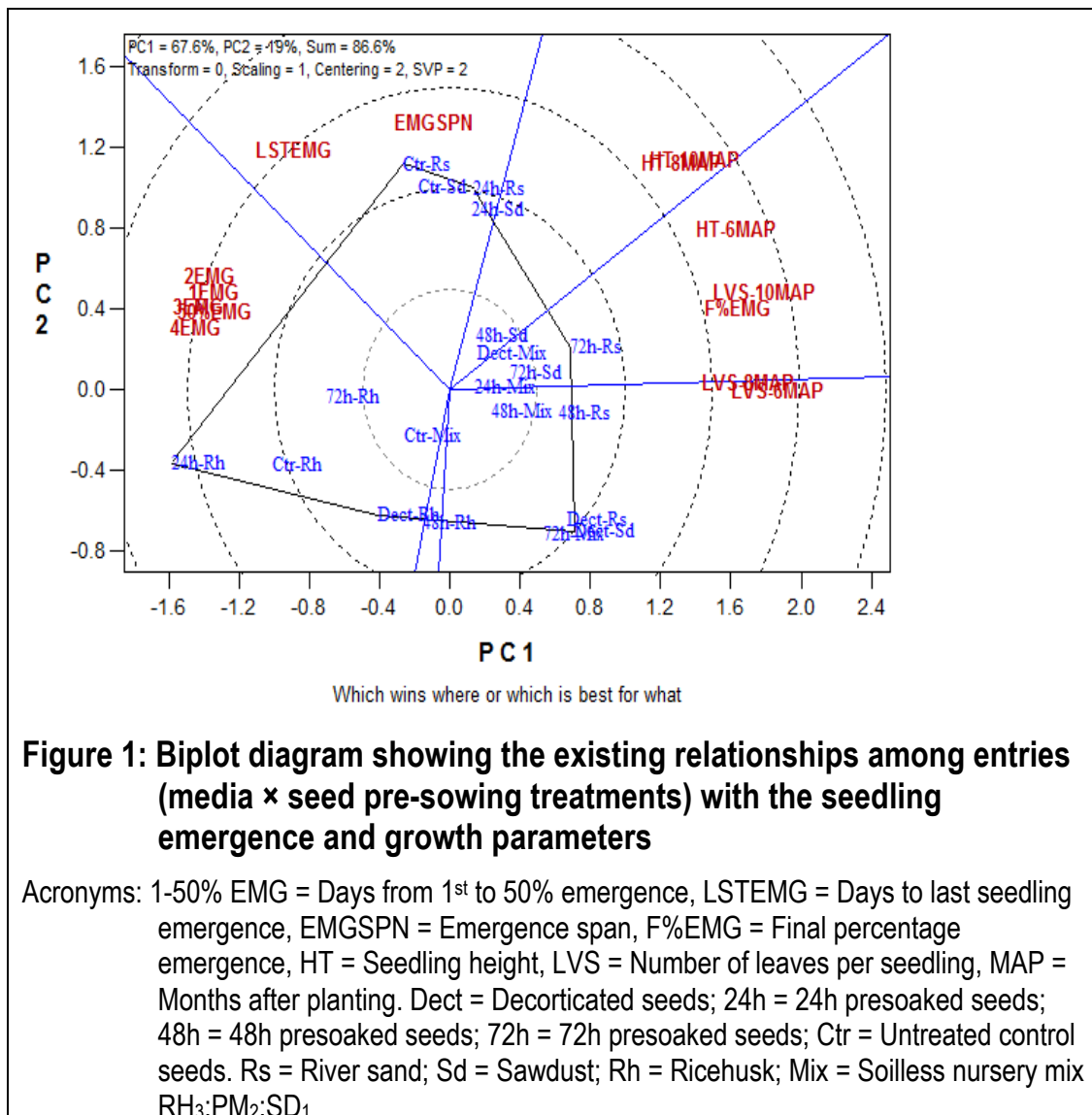
Interestingly, the decorticated seeds with the 48 h and 72 h presoaked seeds recorded 100% emergence in river sand. The decorticated seeds also had 100% emergence in the sawdust and the formulated soilless medium RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub>. Irrespective of seed pre-sowing treatments, the poorest emergence was recorded in the rice husk medium, particularly with the untreated control seeds. The 100% emergence attained by the decorticated seeds (and the 48 and 72 h presoaked seeds) raised in river sand and the sawdust medium (for decorticated seeds) are indications that sawdust and river sand are ideal potting substrates for germinating *G. kola* seeds under humidity chamber environment, following soaking or decortication treatment. Since river sand and sawdust are inert materials used mainly as aerators in nursery media formulations, it would mean that bitter *kola* seeds possess sufficient food reserve in the fused cotyledons that would sustain the seedlings up to 4–8 leaf stage, when the seedlings would be due for weaning to well-composted nursery mixture (see the picture in Plate 3).



**Plate 3: Bitter *kola* seedlings growing luxuriantly under high humidity growth chamber at 10 months after planting**

Data presented in Table 3 show that bitter *kola* seeds presoaked for 72 h and raised in river sand produced the tallest seedlings at 6 months after planting (MAP). Seed pre-sowing treatments did not significantly influence the height of the seedlings at 8 and 10 MAP; however, the tallest seedlings were observed from the presoaked seeds (irrespective of soaking duration) and the decorticated seeds raised in river sand or sawdust medium. Across the growth media, river sand and sawdust produced the tallest seedlings. Conversely, the rice husk medium had the shortest seedlings.





Seed pre-sowing treatments, nursery growth media and their interaction significantly ( $p < 0.05$ ) influenced the number of leaves produced by the bitter *kola* seedlings (Table 4). Across the seed treatments, seed decortication, 48 h and 72 h soaking durations produced seedlings with the highest number of leaves. Similarly, river sand, sawdust and the formulated soilless medium RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> produced seedlings with a greater number of leaves compared to the rice husk medium. However, irrespective of seed pre-sowing treatments, the rice husk medium produced the poorest seedlings (in height and number of foliage leaves).

These observations suggest that seed decortication or presoaking in water (for 48–72 h) before sowing in river sand or sawdust medium would enhance prompt

germination and seedling emergence in *G. kola* and support vigorous seedling growth and development. The biplot chart (Figure 1) explained 86.6% of the total variation existing in the combined effects of nursery growth media and seed pre-sowing treatments on the seedling emergence and growth parameters. The entries (seed treatment × media interaction) located around each vertex of the polygon were the best performed for the traits directly facing the vertex and the poorest for those other traits in the opposite direction.

The 72 h and 48 h presoaked seeds raised in river sand medium had the best seedling performance (in terms of height and number of leaves per seedling at 6, 8 and 10 MAP); these treatment combinations also recorded the highest final emergence percentage together with the decorticated seeds raised in river sand or sawdust, and the 72 h presoaked seeds raised in the soilless nursery mix RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub>. Conversely, the 24 h presoaked seeds with the untreated control seeds raised in rice husk (located around the opposite vertex) had the poorest emergence and seedling growth performance. The control seeds with the 24 h presoaked seeds raised in river sand or sawdust had the widest emergence span and the longest days to last seedling emergence. The decorticated seeds raised in river sand or sawdust and the 72 h presoaked seeds raised in the soilless nursery mix RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> had the least emergence span. All other entries within the central concentric circle of the biplot had an average performance for the emergence, and seedling growth parameters studied. The discernable variability in seedling emergence and growth parameters observed in this study is indicative of seed dormancy problems associated with *Garcinia kola*. The results presented suggest that seed decortication or soaking seeds in water (for 48–72 h) before sowing in river sand or sawdust medium enhances emergence and seedling growth of *G. kola* under humidity growth chamber.

The key environmental factors necessary for embryonic growth and development in many seeds are access to moisture and adequate aeration (for gaseous exchange and cellular respiration), a suitable range of temperature, freedom from high concentrations of inorganic salts and growth inhibitors [10, 28], and for some seeds, exposure to a proper sequence of light and darkness. Aside from moisture availability and adequate aeration, the temperature (warmth) of the seedling growth environment is paramount and should be considered during seed planting [29]. The humidity growth chamber would have enhanced the seed germination of *G. kola* through a consistent provision of a warm, humid and seemingly translucent environment similar to conditions under a natural forest where *G. kola* could germinate. The successful germination of four months stored seeds achieved in this study is indicative that bitter *kola* seeds could remain viable in storage under



room temperatures, provided the seeds are not desiccated. The 100% emergence and vigorous seedling growth recorded with the decorticated seeds and the 48–72 h presoaked seeds sown in river sand or sawdust medium under the warm humidity growth chamber suggest that *G. kola* seedlings could be raised with ease by intending farmers using simple and scalable techniques. The use of high humidity growth chamber– a miniature greenhouse is a simple technology which can easily be adopted by local and peri urban farmers in commercial propagation of bitter kola, provided that wood and the transparent polyethylene cover are available.

## CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

For prompt germination of bitter *kola* seeds with vigorous seedling growth, seed decortication or soaking for 48–72 h are recommended pre-sowing treatments. As regards the potting media, river sand gave the best results (in terms of emergence and seedling growth indicators). Sawdust and the soilless medium (RH<sub>3</sub>:PM<sub>2</sub>:SD<sub>1</sub> – a mixture of rice husk, poultry manure, and sawdust in volume ratios of 3:2:1) are equally suitable for raising bitter *kola* seedlings under humidity chamber conditions. These practices are hereby recommended for regenerating *G. kola* seedlings and rootstocks for commercial planting.

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## Declaration of interest

The authors wish to declare that there are no conflicts of interest associated with this research work.





**Table 1: Main effect of nursery media and seed pre-sowing treatments on seedling emergence parameters of bitter kola (*Garcinia kola* Heckel)**

Nursery media	Days to seedling emergence						Emergence span (days)	Final percentage emergence (%)
	1 <sup>st</sup> emergence	2 <sup>nd</sup> emergence	3 <sup>rd</sup> emergence	4 <sup>th</sup> emergence	50% emergence	Last emergence		
River sand	74.0	83.0	88.4	96.2	102.3	163.0	88.9	95.3
Rice husk	104.7	118.6	136.4	160.0	169.2	178.7	74.0	55.9
Sawdust	81.8	94.2	97.8	103.7	112.2	161.3	79.5	90.0
RH+PM+SD	69.6	75.3	80.5	95.7	105.7	166.1	96.5	86.8
F-LSD <sub>(0.05)</sub>	15.3	12.9	12.2	16.9	16.9	n.s.	n.s.	8.3
<u>Seed treatment</u>								
Decortication	64.6	72.0	79.3	101.3	103.3	126.4	61.8	90.0
24h soaking	101.9	109.2	116.3	128.8	139.9	203.8	102.0	78.8
48h soaking	75.3	85.0	89.8	97.2	105.2	153.1	77.8	84.9
72h soaking	70.6	82.9	90.7	102.9	111.2	148.2	77.7	87.5
Control	100.3	114.7	127.7	139.4	152.2	204.8	104.5	68.8
Mean	82.5	92.8	100.8	113.9	122.4	167.3	84.7	82.0
F-LSD <sub>(0.05)</sub>	17.1	14.4	13.6	18.9	18.9	27.1	30.7	9.3
C.V. (%)	25.1	18.5	16.0	20.3	18.8	19.8	44.6	14.7

F-LSD<sub>(0.05)</sub> = Fisher's least significant difference at 5% probability level; C.V. = Coefficient of variation; n.s. = Non significant effect



**Table 2: Combined effects of nursery media and seed pre-sowing treatments on seedling emergence parameters of bitter kola (*Garcinia kola* Heckel)**

Nursery media	Seed treatment	Days to seedling emergence						Emergence span (days)	Final percentage emergence (%)
		1 <sup>st</sup> emergence	2 <sup>nd</sup> emergence	3 <sup>rd</sup> emergence	4 <sup>th</sup> emergence	50% emergence	Last emergence		
River sand	Decortication	49.3	56.3	58.7	66.0	67.0	92.3	43.0	100.0
	24h soaking	84.3	97.7	105.3	118.0	127.0	218.0	133.7	93.3
	48h soaking	62.0	70.0	72.3	75.7	79.3	130.3	68.3	100.0
	72h soaking	59.3	66.7	70.3	72.0	77.3	142.3	83.0	100.0
	Control	115.3	124.3	135.3	149.3	161.0	232.0	116.7	83.3
Rice husk	Decortication	87.1	104.8	122.3	141.7	125.9	151.5	64.4	60.0
	24h soaking	156.5	158.1	170.0	199.0	217.0	217.0	60.5	52.2
	48h soaking	81.3	93.0	104.5	122.0	138.9	139.0	57.7	53.0
	72h soaking	92.3	117.3	134.0	166.5	178.0	198.7	106.4	63.3
	Control	106.3	119.7	151.0	171.0	186.0	187.3	81.0	51.1
Sawdust	Decortication	58.3	61.0	63.0	66.3	69.7	93.0	34.7	100
	24h soaking	93.3	104.3	106.7	110.0	115.0	195.3	102.0	83.3
	48h soaking	86.7	100.3	104.0	109.0	111.7	162.0	75.3	93.3
	72h soaking	67.0	82.3	89.3	102.0	110.7	141.0	74.0	93.3
	Control	103.7	123.0	126.0	131.0	154.0	215.3	111.6	80.0
RH+PM+SD	Decortication	63.7	66.0	73.3	131.0	150.7	168.7	105.0	100
	24h soaking	73.3	76.7	83.3	88.0	100.7	185.0	111.7	86.7
	48h soaking	71.3	76.7	78.3	82.3	91.0	181.0	109.7	93.3
	72h soaking	63.7	65.3	69.3	71.0	78.7	111.0	47.3	93.3
	Control	76.0	91.7	98.3	106.3	107.7	184.7	108.7	60.6
Mean		82.5	92.8	100.8	113.9	122.4	167.3	84.7	82.0
F-LSD <sub>(0.05)</sub>		34.1	28.8	27.2	37.7	37.8	54.1	n.s.	18.5
Coefficient of variation (%)		25.1	18.5	16.0	20.3	18.8	19.8	44.6	14.7



**Table 3: Effect of nursery media and seed pre-sowing treatments on seedling height (cm) of bitter *kola* (*Garcinia kola* Heckel) measured at 6, 8 and 10 months after nursery planting (MAP)**

Seedling height (cm) at 6 MAP						
Nursery media	Decortication	Seed pre-sowing treatments			Control	Mean
		24 h soaking	48 h soaking	72 h soaking		
River sand	12.1	11.7	12.7	13.9	12.6	12.6
Rice husk	7.4	1.8	9.4	8.0	6.2	6.6
Sawdust	11.4	12.5	12.5	12.0	12.7	12.2
RH+PM+SD	11.6	9.2	10.2	10.3	8.5	9.9
Mean	10.6	8.8	11.2	11.1	10.0	10.3

F-LSD<sub>(0.05)</sub> for comparing two nursery media = 1.0; F-LSD<sub>(0.05)</sub> for seed treatments means = 1.1;  
F-LSD<sub>(0.05)</sub> for interaction effect (media × seed treatment) = 2.2; Coefficient of variation (%) = 12.7

Seedling height (cm) at 8 MAP						
Nursery media	Decortication	Seed pre-sowing treatments			Control	Mean
		24 h soaking	48 h soaking	72 h soaking		
River sand	13.5	14.6	14.4	15.2	14.5	14.4
Rice husk	10.7	9.7	11.9	10.1	10.3	10.5
Sawdust	13.2	16.3	14.5	14.6	15.6	14.8
RH+PM+SD	13.4	12.7	11.9	12.4	11.5	12.4
Mean	12.7	13.3	13.2	13.1	13.0	13.0

F-LSD<sub>(0.05)</sub> for comparing two nursery media = 0.8; F-LSD<sub>(0.05)</sub> for seed treatments means = n.s.  
F-LSD<sub>(0.05)</sub> for interaction effect (media × seed treatment) = 1.9; Coefficient of variation (%) = 9.1

Seedling height (cm) at 10 MAP						
Nursery media	Decortication	Seed pre-sowing treatments			Control	Mean
		24 h soaking	48 h soaking	72 h soaking		
River sand	14.9	17.1	15.2	16.4	15.8	15.9
Rice husk	10.6	8.4	10.2	11.0	9.5	9.9
Sawdust	14.9	18.3	15.4	15.8	16.5	16.2
RH+PM+SD	14.6	12.6	12.7	12.8	11.4	12.8
Mean	13.7	14.1	13.4	14.0	13.3	13.7

F-LSD<sub>(0.05)</sub> for comparing two nursery media = 1.0; F-LSD<sub>(0.05)</sub> for seed treatments means = n.s.  
F-LSD<sub>(0.05)</sub> for interaction effect (media × seed treatment) = 2.2; Coefficient of variation (%) = 9.5



**Table 4: Effect of nursery media and seed pre-sowing treatments on the number of leaves per bitter *kola* (*Garcinia kola* Heckel) seedling recorded at 6, 8 and 10 months after nursery planting (MAP)**

**Number of leaves per seedling at 6 MAP**

Nursery media	Decortication	Seed pre-sowing treatments			Control	Mean
		24 h soaking	48 h soaking	72 h soaking		
River sand	4.7	4.0	5.0	4.6	3.7	4.4
Rice husk	2.8	1.0	4.0	2.7	1.4	2.4
Sawdust	5.6	3.6	3.9	4.3	3.5	4.2
RH+PM+SD	3.9	3.6	4.5	4.6	2.9	4.0
Mean	4.3	3.1	4.4	4.1	2.9	3.8

F-LSD<sub>(0.05)</sub> for comparing two nursery media = 0.5; F-LSD<sub>(0.05)</sub> for seed treatments means = 0.6;  
F-LSD<sub>(0.05)</sub> for interaction effect (media × seed treatment) = 1.1;  
Coefficient of variation (%) = 18.7

**Number of leaves per seedling at 8 MAP**

Nursery media	Decortication	Seed pre-sowing treatments			Control	Mean
		24 h soaking	48 h soaking	72 h soaking		
River sand	4.4	4.9	5.3	5.0	4.4	4.8
Rice husk	4.5	2.3	5.3	3.7	3.3	3.8
Sawdust	5.2	4.6	4.7	4.8	4.6	4.8
RH+PM+SD	4.4	4.9	5.4	5.6	3.9	4.8
Mean	4.6	4.2	5.2	4.8	4.0	4.6

F-LSD<sub>(0.05)</sub> for comparing two nursery media = 0.6; F-LSD<sub>(0.05)</sub> for seed treatments means = 0.6  
F-LSD<sub>(0.05)</sub> for interaction effect (media × seed treatment) = 1.3;  
Coefficient of variation (%) = 16.6

**Number of leaves per seedling at 10 MAP**

Nursery media	Decortication	Seed pre-sowing treatments			Control	Mean
		24 h soaking	48 h soaking	72 h soaking		
River sand	7.6	8.1	7.6	8.8	7.4	7.9
Rice husk	5.5	2.7	5.5	5.1	3.8	4.5
Sawdust	7.5	7.2	6.6	7.1	6.1	6.9
RH+PM+SD	6.1	7.2	5.8	7.9	5.7	6.5
Mean	6.7	6.3	6.4	7.2	5.7	6.5

F-LSD<sub>(0.05)</sub> for comparing two nursery media = 0.8; F-LSD<sub>(0.05)</sub> for seed treatments means = 0.8  
F-LSD<sub>(0.05)</sub> for interaction effect (media × seed treatment) = 1.7;  
Coefficient of variation (%) = 15.7





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